AD-A170 939

Research Report 1381

Field Trials of the MK60 Tank Gunnery Simulator in Armor Institutional Training Courses, Volume I: Final Report

R. Gene Hoffman and William H. Melching
Human Resources Research Organization

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ARI Field Unit at Fort Knox, Kentucky
Training Research Laboratory

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REPORT DOCUMENTATION PAGE	READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER: ARI Research Report 1381	2. GOVT ACCESSION NO. AD-A170 939
	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle): FIELD TRIALS OF THE MK60 TANK GUNNERY SIMULATOR IN ARMOR INSTITUTIONAL TRAINING COURSES, VOLUME I: FINAL REPORT	5. TYPE OF REPORT & PERIOD COVERED: Final Report February 1983-October 1984
	6. PERFORMING ORG. REPORT NUMBER: FR-TRD(KY)-82-9
7. AUTHOR(s): R. Gene Hoffman, William H. Melching	8. CONTRACT OR GRANT NUMBER(s): MDA903-81-C-0534
9. PERFORMING ORGANIZATION NAME AND ADDRESS: Human Resources Research Organization (HumRRO), 1100 South Washington Street, Alexandria, VA 22314	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: 2Q263743A794, Work Unit 5410
11. CONTROLLING OFFICE NAME AND ADDRESS: U.S. Army Research Institute for the Behavioral and Social Sciences, 5001 Eisenhower Avenue, Alexandria, VA 22333-5600	12. REPORT DATE: October 1984
	13. NUMBER OF PAGES: 156
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office): --	15. SECURITY CLASS. (of this report): Unclassified
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE: --

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

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18. SUPPLEMENTARY NOTES

Research performed by HumRRO, Fort Knox Office, P.O. Box 293, Fort Knox, Kentucky 40121, and monitored by David W. Bessemer, ARI Field Unit at Fort Knox. Volume II of this report has been published as ARI Research Note 84-60, February 1984.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Armor
Armor training
Tank gunnery simulator

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Training simulators, developed to ease the burden on resources and to provide low-cost alternatives, must be field tested prior to their use. This report describes the field trials of the Perceptronics MK60, a part-task tank gunnery simulator which through computer control (1) presents target engagements recorded on a videodisc, (2) enables students to operate switches and controls, track and fire, and (3) provides feedback about their performance. The purpose of the field trials was to assess, in an institutional (Continued)

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setting (1) the training effectiveness of the MK60 for teaching gunnery skills, (2) the transfer of that training to M60A1 tank performance, (3) the validity of the MK60 for predicting M60A1 performance of individual soldiers, and (4) the opinions of students and instructors. Field trials were conducted with Armor Officer Basic students and with enlisted students in Basic Armor Training. Two intensities of simulator training were compared to the normal programs of instruction. Results indicated that (1) performance on the simulator increased as a direct function of practice time, with improvements in speed of achieving target hits and in consistency of gunner verbal responses; (2) transfer of training from the MK60 to dry fire and live fire on the M60A1 tank appeared equal to that of the devices currently used in gunnery training; (3) the MK60 was not predictive of individual soldiers' M60A1 performance; and (4) students and instructors found the simulator challenging, realistic and they were very favorable toward its use.

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Field Trials of the MK60 Tank Gunnery Simulator in Armor Institutional Training Courses, Volume I: Final Report

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for

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Office, Deputy Chief of Staff for Personnel
Department of the Army

October 1984

Army Project Number
2Q263743A794

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FOREWORD

Advances in videodisc and computer technologies spawn innovative solutions to Army training needs. One such innovation is a part-task tank gunnery simulator which can, unlike current trainers, present practice on targets that make realistic movements and maneuvers in real terrain. The simulator is a low-cost, tabletop device which, like the new electronic arcade games, requires the student to track targets and fire; it graphically displays projectile trajectories and hit explosions and keeps score. The device, called the MK60, is designed to be challenging and appealing.

Such devices, however, cannot be implemented in training based on their appeal and sophistication alone. They must be tested in field settings to answer questions about their training capabilities. The Fort Knox Field Unit of ARI uses the methodology of experimental psychology to answer such Army training system questions. The Simulation Systems Team performs research and development on the effectiveness of devices, aids, and simulators for improving Armor training. In this field test, attention was turned to such questions about the MK60 simulator as: Can students learn M60A1 gunnery skills on the device? Do these skills transfer to M60A1 performance? Can the MK60 be used to predict the performance of individual soldiers? What are the opinions of students and instructors about the device? The results of these field tests should be of interest to designers and developers of tank gunnery training as well as to developers of technologically advanced training devices.

EDGAR M. JOHNSON
Technical Director

FIELD TRIALS OF THE MK60 TANK GUNNERY SIMULATOR IN ARMOR INSTITUTIONAL TRAINING COURSES

EXECUTIVE SUMMARY

Requirement:

Conduct initial field trials of a prototype version of the Perceptronics MK60, a part-task M60A1 tank gunnery simulator, in the institutional settings of Armor Officer Basic (AOB) and Basic Armor Training (BAT) courses.

Procedure:

For both AOB and BAT courses, three groups of students were monitored during their M60A1 conduct of fire training. Two groups of students received MK60 training, each at a different level of intensity; the third group received the regular program of instruction. AOB students receiving MK60 instruction practiced for either one or two hours. BAT students receiving MK60 instruction practiced for either three or four hours. Students in all groups were administered MK60 tests before and after training. They were also administered specially prepared dry fire exercises on moving targets recorded using through-the-sight video cameras. Technical difficulties were encountered which reduced the reliability of some of the measures associated with the dry fire analyses. Score cards for Tank Table VIA, main gun firing at stationary and moving targets, were obtainable for BAT students only. Students and instructors who administered MK60 training completed opinion questionnaires. A "no treatment" (i.e., no conduct of fire training) control group was not practical and therefore transfer assessment was relative to current methods rather than absolute.

Findings:

There was consistent evidence from both the AOB and BAT field trials that students did improve their performance on the MK60. Their improvement appeared to be due primarily to speed of responding on the MK60. For the dry fire M60A1 exercises, no consistent significant differences among training groups were found. For the AOB, there was a suggestion of faster responding for MK60-trained students. M60A1 live fire scores for BAT students did not differ among the training groups. The questionnaire data revealed consistently favorable attitudes to the MK60 for both students and instructors.

Utilization of Findings:

Given that this initial version of the MK60 performed as well as the more well established current method, a number of suggestions for modifications and improvements for the MK60, if implemented, may increase the training value of the MK60. For example, students learn to respond rapidly but without increased

accuracy. Consequently, they do not learn to conserve ammunition. By changing the programming of the MK60 computer, less emphasis could be given to speed and more emphasis to achieving first round hits. Other changes which would increase the number of M60A1 gunnery training objectives which could be practiced include the addition of M105D telescope reticles, modification of the video output channel so that an instructor could see the aiming point of the student, improve the clarity and stability of the video picture and provide additional videodisc practice engagements which more closely support training objectives.

FIELD TRIALS OF THE MK60 TANK GUNNERY SIMULATOR IN ARMOR INSTITUTIONAL TRAINING COURSES

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FIELD TRIALS OF THE MK60 TANK GUNNERY SIMULATOR IN ARMOR INSTITUTIONAL TRAINING COURSES

VOLUME I: FINAL REPORT

INTRODUCTION

There is a continuing need in the U.S. Army for soldiers to attain and maintain specific combat skills. Often, however, this need encounters severe constraints. In Armor training, for example, personnel turbulence and the rising costs of tank main gun ammunition, fuel, and spare parts make it difficult to develop and maintain skilled tank crews. In addition, tank units frequently cannot get access to needed tank ranges to fire as often as they should. To overcome limitations such as these, Armor training institutions have sought to meet training requirements through simulation, miniaturization, or substitution.

Various approaches have been tried, but none has been without problems. For example, while dry-fire training does not require ammunition, it does require the presence of operational tanks and, without costly add-on equipment, provides limited feedback. Thus, it is only a partial solution to the problem. Similar problems prevail with respect to the use of subcaliber devices; tanks are needed plus access to ranges. High fidelity simulators offer a possible solution, but they tend to be costly, hard to maintain, and not sufficiently plentiful.

The end result of this is that soldiers are often limited in their opportunity to practice critical job tasks. Without appropriate practice, they do not develop the level of skill needed for effective job performance. When the missing skill is vital to combat, the problem cries for attention.

Military Problem

Because of the costs associated with equipment, facilities, and ammunition, tank personnel (especially tank gunners) do not get the hands-on practice and experience they need to attain and retain their job skills. This situation characterizes both the institutional training setting and the unit setting. What is needed in tank gunnery is a realistic, relatively low-cost, easy to maintain device that will give the tank crewman an opportunity to practice some of the more important gunnery tasks associated with his MOS. If such devices were made available to gunners during their regular classroom instruction, and/or placed in convenient places within the unit where they could be readily used, a significant improvement might occur in the proficiency level of the gunner.

A potentially useful tank gunnery simulator with the desired properties currently exists. Manufactured by Perceptronics, Inc., it has been designated the MK60. Based on an early prototype model, the device offers promise that it may provide tank crewmen with the hands-on practice and experience they need to become skilled gunners. To judge the usefulness of the MK60 as

a training device in an institutional setting, a careful field trial must be undertaken. Only then can appropriate decisions be made with regard to the merit of employing the device in beginning tank gunnery training.[1] The purpose of the present field trial is to assess: (1) the training effectiveness of the MK60 for teaching gunnery skills, (2) the transfer of that training to M60A1 tank performance, (3) the validity of the MK60 for predicting M60A1 performance of individual soldiers, and (4) the opinions of students and instructors.

Description of Device

The major components of the MK60 consist of a gunner's console, a videodisc player, and a floppy disc drive unit. A close-up view of the console is found in Figure 1, while the typical manner in which components are configured is shown in Figure 2.

Gunner's Console

The gunner's console is a compact table top electronic unit that simulates the M60A1 gunner's station. A microcomputer is contained inside the unit. The console (Figure 1) has ON/OFF switches comparable to those on the M60A1, including power, stabilization, elevation/traverse, main gun, and coax.[2] Each switch has an indicator light. The switches and lights operate as they would in the M60A1 gunner's station, e.g., the main gun switch must be ON in order to fire a main gun round. An ammunition selector control is provided, and its display denotes the position of the selector.

Other significant features are the gunner's sight display and gunner's power control (cadillacs). The sight display consists of a non-adjustable optical sight, a projected M32 periscope reticle, and a CRT that shows full color target scenes and computer generated graphics showing hits, misses, and tracers. The gunner's power control enables the gunner to traverse and elevate the gun. This control has palm switches and trigger switches like those in the turret of the M60A1. That is, the palm switches must be depressed to track a target, and the main gun switch must be turned on in order to fire on a target.

Special features on the MK60 console consist of a CRT Scoreboard display and an input keypad. They are used in programming engagements on the device and, during practice, in reporting a variety of information about a gunner's performance on a given engagement. This information includes the current engagement number, possible score on the engagement, actual score obtained, seconds elapsed during the engagement, rounds used, average miss distance in mils, and cumulative total of engagement scores during practice session.

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[1] It was originally planned that two simulators would be examined, the MK60 and the Battle Zone game manufactured by ATARI, Inc. However, the latter device was not made available.

[2] The stabilization capability was not a part of the present field trial. No videodisc problems were provided which simulated firing from a moving tank.

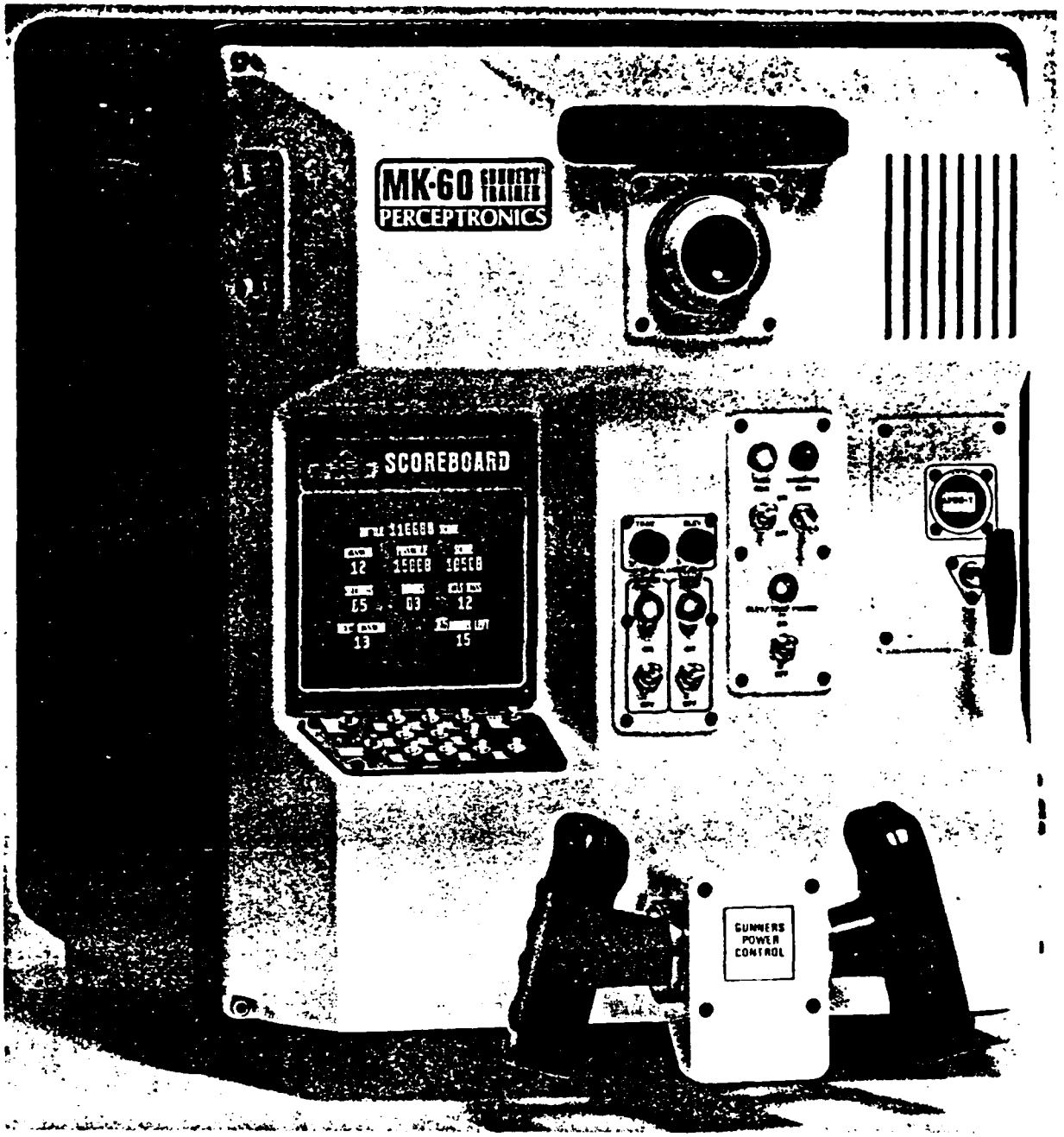

Figure 1. MK60 Gunner's Console

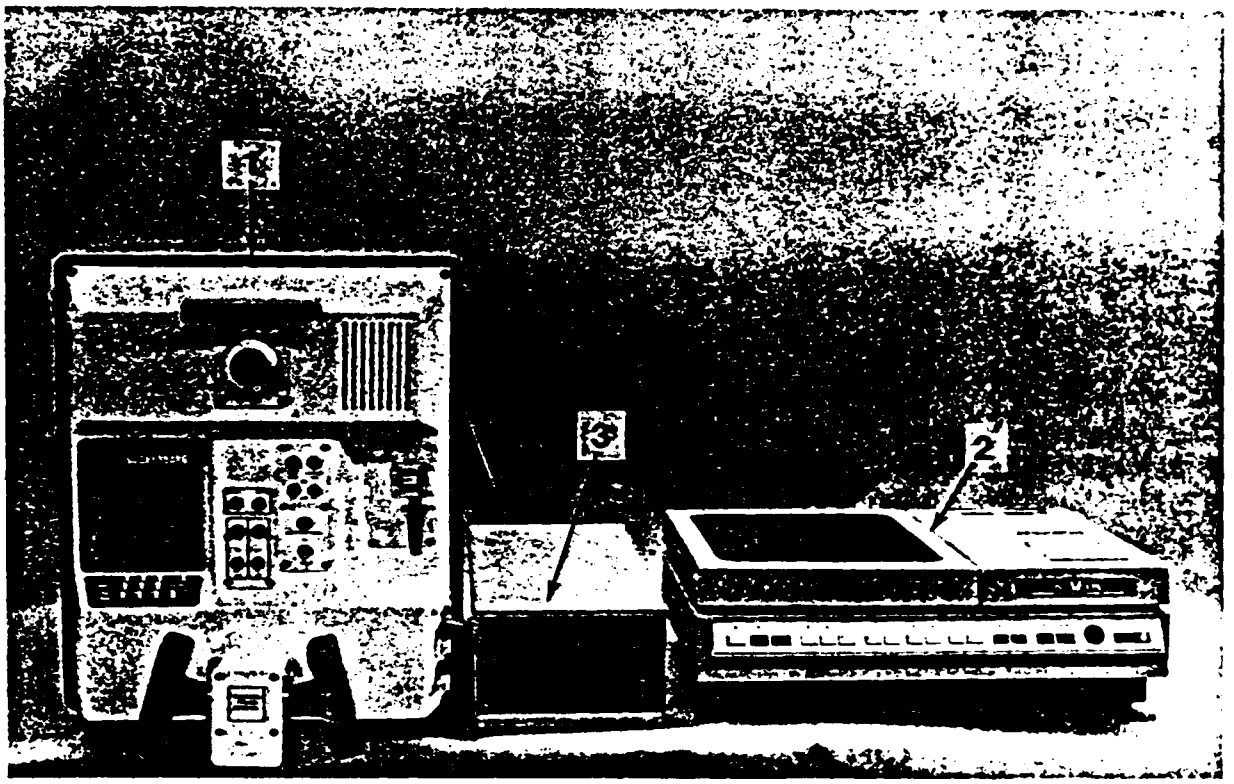

Figure 2. MK60 Components: (1) Gunner's Console, (2) Videodisc player, (3) Floppy diskette Reader.

Associated features consists of a key switch, a built-in speaker, a knob to control reticle brightness, and a knob to control speaker volume. All fire commands and battle sound effects are delivered through the speaker. A headset jack is also provided, and it may be used in lien of the built-in speaker for fire commands and sound effects. Head sets were not used in the present field trial. The key switch has three positions: (1) PROG, which enables one to program a specific set of engagements, (2) ON, which enables the student to practice a set of engagements, and (3) OFF, which turns off all power to the device.

Videodisc Player

The videodisc player combines the use of lasers, microprocessors, and electronic semiconductor devices to produce a picture from the videodisc. Operation of the player requires only that the videodisc be placed in position and that power be supplied to the player. All functions performed by the player are controlled by the microcomputer in the gunner's console.

There are several controls and indicators on the player, but only the POWER button and COVER OPEN button require operator action. To place a videodisc in the player, the key switch of the gunner's console must be set at ON. This enables the cover to be opened and a videodisc to be locked into place. When the cover is lowered, the player can then operate.

Floppy Disc Drive Unit

The floppy disc drive unit contains drive and track position mechanisms, electronics, and a removable diskette. The components of the unit work together to interpret and generate control signals which influence both the videodisc player and the computer inside the gunner's console.

The unit has two controls and one indicator. The controls are a cover and cover release. The cover must be closed after the diskette is inserted; this enables the unit to operate. It is necessary to press the cover release to remove the diskette. The cover release does not have to have power to operate. In the middle of the cover release is a small indicator lamp. When lit, it indicates that the unit is reading information from the diskette. When the diskette is put into the unit and the unit is powered, this light will appear for approximately 10 to 20 seconds. During this time the program is being loaded into the microcomputer in the gunner's console.

Overview of the Field Trial Design

The general plan of the field trial was to give a randomly selected set of subjects specific opportunities to practice gunnery tasks on the device, and then to compare their subsequent dry and live fire performance with performance of another randomly selected set of subjects who were given regular training and no practice on the device.

It was originally planned to use as subjects only those soldiers currently undergoing Basic Armor Training (BAT) for MOS 19E (M60A1 Tank Crewman). However, because there were delays in obtaining the device and device materials, the gathering of performance data from BAT could not proceed as scheduled. It was therefore decided to modify the field trial and include persons attending Armor Officer Basic (AOB) training as subjects. This would reduce the burden on the BAT companies, and not interfere with their need to accomplish other important missions. As a result of this decision, two studies were planned, one to examine the effectiveness of the MK60 for AOB students, and one to examine the MK60 for BAT students. The AOB study involved three classes of students; in the BAT study there were four classes or companies. Training and testing procedures were kept as similar as possible; however, scheduling differences between the AOB and BAT programs of instruction made it necessary to treat the research as two separate field trials.

For M60A1 gunnery instruction, AOB and BAT each normally develop students by the sequential use of three types of training devices. After introductory lectures, students first practice gunnery procedures using the Willey Burst on Target trainer. Using a slide projector and series of mirrors, the Willey requires students to look through a gunner's sight, search for and lay on stationary targets by manipulating a set of tank gunner hand controls. Main gun, coax and ammo switches are represented. The gunner's sight picture is also presented on a screen on the front of the trainer for the instructor to use to provide feedback to the student concerning his laying technique. The Willey can present either M32 periscope or M105D telescope reticles. Systematic errors can be induced by the instructor, allowing the student to practice the Burst on Target (BOT) method of fire adjustment. The second training device used in AOB and BAT instruction is the Brewster mounted M55 Laser. This is a laser device mounted on an actual M60A1 tank or on an M60A1 turret trainer. Obviously, the gunner controls are the actual tank controls. The laser projects the student's aiming point to a target board or down a miniature range which may be set up to include stationary and moving targets. The third training device is the .22 cal Brewster device. This is essentially an M16 rifle mounted parallel to the gun tube of an M60A1. The students can fire on stationary or moving targets on a miniature range. During the period of this project, no AOB students were receiving instruction with the .22 cal Brewster device.

The research design included both substitution of MK60 training for portions of the normal M55 Laser and additional MK60 training. That is, the field trials AOB and BAT students were scheduled to receive MK60 training in place of a portion of their M55 Laser training. In addition, one half of the field trial students were scheduled to receive additional MK60 training during time not normally devoted to gunnery training. Thus, the design of the field trial allows a comparison of MK60 effectiveness to M55 Laser effectiveness, with MK60 training presented at two levels of intensity.

For a number of reasons, the MK60 was not substituted for the Willey trainer. First, there are a number of procedural steps the student must master in response to the tank commander's fire commands. While these steps are not particularly difficult (turn on main gun or coax switch, announce "identified", index the correct ammo, announce "on the way", announce a sensing or observation of where the round impacted, and turn off main gun

switch after hearing TC announce "cease fire"), students often make mistakes when first learning these steps and require practice before their responses become automatic. Students in the normal training receive this practice on the Willey. When they make mistakes, the instructor who issues the fire command can stop, give them feedback and immediately repeat the fire command for the student to try again. Using the MK60 the instructor cannot stop the engagement presentation after it has started. The training engagements provided by Perceptronics ran anywhere from 45 seconds to over one minute. By the time an engagement was over, a student's initial error in responding to the initial fire command has been overshadowed by the tracking and firing aspects of the engagement. Thus, the Willey seemed better suited for the beginning practice of responding to initial fire commands.

A second apparent advantage of the Willey over the MK60 for the initial phase of instruction was the MK60's lack of a sight picture presentation for the instructor. A video monitor was acquired for each MK60 which allowed the instructor to see the target, tracers and bursts, but not the sight reticle. Thus, the instructor could not give feedback about a student's sight picture, except by inferring what it was from the burst representation. With no mil graduations on the video monitor, the instructor's feedback would be limited to simply "over," "short," "left" or "right."

A third apparent advantage of the Willey for initial gunner practice was that the MK60 practice engagements provided by Perceptronics included no stationary targets. While acquiring a sense of the operational characteristics of the gunner's control handle may be a skill which is rapidly acquired, previous experience with testing novice gunner students (e.g., Campbell & Black, 1982) has shown that initially students can become confused with the relationship between manipulation of the controls and the resulting change in sight picture. The stationary targets of the Willey favor it as the introductory device for learning this relationship. That is, students are required only to move from one point (the initial aiming point) to another (the stationary target) rather than from one point to a constantly moving point (the moving target).

A fourth advantage of the Willey was the capability of representing the M105D telescope ballistic reticles as well as the M32 non-ballistic reticle. Mastery of the M105D telescope reticle is difficult because the aiming point is dependent on the range of the target. On the other hand, the aiming point for the M32 reticle does not depend on target range. Thus, mastery of the M32 reticle alone will not transfer to mastery of the M105D without specific practice using the M105D telescope reticle.

The final apparent advantage of the Willey concerned learning to respond to subsequent fire commands. Essentially, responding to a subsequent fire command involves selecting a new aiming point on the reticle based on the instructions of the TC. Using the Willey, the instructor can check the correctness of the student's selection by viewing the student's sight picture presented on the screen on the front of the Willey. Using the MK60, there is no direct way to check the correctness of the student's response.

Based on the accumulation of these advantages of the Willey over the MK60 for initial gunnery practice, the evaluation plan did not call for the substitution of the MK60 for any portion of Willey training. It should be

noted that many of these limitations of the MK60 may be correctable in future modifications (See Appendix D to Volume I).

To summarize the test design, two groups of MK60 trained students were specified. These two groups were to receive two different levels of MK60 training in place of a portion of the normally scheduled M55 Laser training. A control group of students who participated in the normal training was also monitored. Training effectiveness was examined as improvement during MK60 training and training transfer was examined as performance on M60A1 exercises. In addition, training opinions of students and instructors were gathered. Correlations between MK60 and M60A1 performance assessed test validity of the MK60.

Testing Criteria

To assess the training capabilities of the MK60, four types of testing criteria were selected: (1) attitudinal evaluation of the MK60, (2) end-of-course performance on the MK60, (3) performance on a video-taped, dry-fire exercise conducted on the M60A1 tank, and (4) performance on live main gun firing on the M60A1 as specified by Tank Table VI in FM 17-12, as modified by the AOB and BAT programs of instruction.

Students' attitudes toward training can have a significant impact on the effectiveness of a training program. Programs that stimulate and challenge the student can increase their motivation to learn. While a student's motivation does not insure learning or transfer of learned skills, lack of motivation can certainly reduce the level of learning that might otherwise occur. For the MK60, this attitudinal component of its evaluation is particularly important because of the plans to utilize the device in field settings where practice time on the device may be largely self-monitored. Positive attitudes toward the device would seem to increase the likelihood of voluntary practice.

The second criterion examined improvement on the MK60 as a result of training as a means of assessing training effectiveness. That is, gunnery students practicing on the MK60 should show significant improvements in performance. While improvement on the MK60 does not insure transfer to the M60A1 tank, lack of transfer of training to the M60A1 tank may be the result of a failure to learn to perform on the device. That is, without establishing that learning occurs on the MK60 itself, it is not possible to fully examine transfer of learning. Thus, MK60 trained and control students received MK60 pretests and posttests. Pretests were scheduled to occur for all participating students after an introductory period of instruction on the Willey but prior to any training on the MK60. Posttests were scheduled just prior to dry fire and live fire exercises after all MK60 training was completed. Because the MK60 is designed to simulate requirements for using M60A1 gunnery skills, and because all groups are receiving some type of gunnery training, the control as well as MK60 trained groups should show significant improvements in performance between the pretest and posttest.

Expectations about relative difference between the control and MK60 trained groups at the end of training were less clear. The control group and low intensity group were designed to have similar amounts of gunnery training

but on different devices. Any difference in posttest performance between these two groups could be attributed to the different training devices and the program of instruction in which they were used. Some of that difference, however, could include MK60 skill requirement idiosyncrasies not learned on the M55 Laser and not required for performance on the M60A1 tank. Thus, there is an unavoidable confounding in the comparison of the control group MK60 posttest performance to low group MK60 posttest performance. Similarly, confounding occurs for the comparison of the control group's MK60 posttest performance and the high intensity group's MK60 posttest performance. If there were no differences between the control and MK60 trained groups on MK60 posttest performance, and there were pretest-posttest improvements for all groups, there would be support for the conclusion that MK60 and M55 laser instruction were essentially equal and that the MK60 has relatively insignificant device specific skill requirements. On the other hand, if the MK60 groups outperformed the control group on the posttest, the difference may be due to higher quality instruction (e.g., the MK60 provides much more practice on moving targets) or to device specific skill requirements, and a conclusion about the MK60 training effectiveness relative to the M55 Laser is dependent upon the dry fire and live fire criteria. Comparison of the high intensity group's posttest performance to the low intensity group's posttest performance would indicate the extent to which additional practice improves performance. It is anticipated that the high intensity group will obtain higher posttest scores than the low intensity group.

To assess transfer of training, two M60A1 firing exercises were designed. Because of the MK60 emphasis on moving targets, assessment of transfer needed to include both stationary and moving targets. While Tank Table VI does specify moving targets be used, they are often unavailable. Furthermore, the MK60 presents targets of varying speed and varying directions. The live fire moving targets that are occasionally available are slow speed, straight line targets. Therefore, a dry fire exercise was specified for the MK60 transfer assessment. Targets of varying speed and direction were laid out to tap moving target gunnery skills. Measurement of dry fire performance was accomplished by the use of through-the-sight video cameras which capture the student's sight picture at the time he fires. Lay errors could then be calculated. Lay errors were assessed in both the vertical and horizontal directions. Because the targets were all moving, lay errors were calculated as the difference between the lead exhibited by the student and the correct lead needed to hit the target. However, there are two ways to define the "correct" lead. First, is the Army policy of teaching "standard leads" which are dependent only on the type of ammunition being fired (i.e., 2.5 mils for APDS, 5 mils for HEAT and 7.5 mils for HEP). On the other hand, there is an optimum lead based on the actual ballistic characteristics of each ammunition which depends on target speed and direction of movement, and target range. Lead errors were calculated using both the optimum lead and the standard lead. While the control students would be expected to use the standard lead, the MK60 students practiced on MK60 targets with varying speed, some of which required leads other than the standard lead in order to achieve a hit. Since the MK60 computes hits by using actual ballistic algorithms, MK60 trained students may learn to use varying leads based on the apparent speed and range of the target.

In addition, the dry fire video tape also included time data which can be used to assess the student's time to acquire the target, and time to lay on the target.

The dry fire test also included assessment of the student gunner's ability to adjust fire by responding to specified subsequent fire commands. Optimum and standard lead errors were calculated to reflect the student's aiming point in relation to the target and the mil corrections announced in the subsequent fire command. For example, if the target was to be engaged with HEAT ammunition, a standard five mil lead should normally be used. If a subsequent fire command directed the student gunner to correct by aiming "left, three mils," then the correct standard lead based aiming point would be eight mils for a right to left moving target or two mils for a left to right moving target. Lead errors based on ballistic optimum leads were calculated in a similar manner. In addition, time data were used to measure each student gunner's time to adjust following these subsequent fire commands.

The final criterion was live fire performance on Tank Table VI. Previous research has well illustrated the difficulty of measuring live fire performance (Eaton & Whalen, 1980); therefore assessment of Table VI performance by through-sight video camera recording on the gunner's sight picture at the time of firing was planned.

Examination of MK60 Simulated Test Validity

The MK60 may also be useful for assessing individual gunner skills in order to make predictions about future performance. The usefulness of the MK60 as a test device has already been alluded to in the discussion of anticipated pretest-posttest differences. To repeat, if all students, MK60 trained and control, showed pretest to posttest improvements in performance and assuming that some learning has occurred, the validity of the MK60 as an assessment of M60A1 gunner skills would be supported. Additional evidence for the validity of the MK60 as a test device will come from a correlational analysis of the relationship between individual MK60 test scores and individual dry fire and live fire scores.

FIELD TRIAL I

Field Trial I examined the capability of the MK60 for providing conduct of fire instruction to AOB students.

Method

Device

The MK60 was described previously. When Field Trial I began, five devices were made available.

Subjects

The subjects for Study I came from three AOB classes, US Army Armor School, Fort Knox, Kentucky. All subjects had received M60A1 Conduct of Fire training in their regular instruction before they were tested or trained on the MK60. None had fired the tank main gun.

Since regular AOB instruction organizes students in "crews" of four students, the same groupings were maintained in the present study. In other words, in selecting students to serve as subjects, crews were selected rather than individual students. The field trial plan called for three groups of subjects, a control group and two MK60 trained groups. MK60 groups differed in amount of training time on the device, and they were referred to as low intensity and high intensity. Each group was to contain eight subjects per class, and for AOB this meant two four-man crews for each group for each class.

Crews were selected for inclusion in the field trial by using a table of random numbers. Crews were numbered. Then the table was entered to select those crew numbers that would be assigned to the field trial. The first two randomly selected crew numbers were assigned to the control group, the next two to the low intensity group, and the last two to the high intensity group. Since one AOB class contained only six crews, they were all selected, but randomly assigned to the field trial conditions.

It was anticipated that each of the three classes would provide 24 students each, or a total of 72 for the evaluation, but one class had only 23 students, so the study began with just 71. Subsequently, it was necessary to drop other students who were absent for various reasons, and this meant that data on even fewer students were available when the results were analyzed.

Training and Testing Materials

All training and testing materials prepared for the field trials were described in some detail in a previous document (Melching & Hoffman, 1982), and copies of all those materials were also included in that report. In

addition, copies of all materials actually used in the field trials are provided in Volume II of the present report.

To aid the reader in understanding the content and function of these materials, each will be described briefly.

Device Training Materials. Several months prior to the field trials, basic tank gunnery training objectives were developed, and sets of tank gunnery engagements were proposed (Melching, Campbell, & Hoffman, 1982). However, delays in production of videodisc materials were experienced by Perceptronics, and the recommended sets of engagements were not produced. Instead, Perceptronics provided for the field trial a videodisc of engagements from existing target films. This videodisc contained 26 engagement scenes; of these, 20 had main gun targets, six had coax targets.

In addition to the videodisc, operation of the MK60 required that software information for each engagement scene be read from a floppy diskette. Perceptronics provided a floppy diskette for this purpose. That diskette allowed access to the 20 main gun engagements, but, due to software difficulties experienced by Perceptronics, it did not allow access to the six coax engagement scenes. For that reason, only the 20 main gun engagements were available for training and testing when the AOB students undertook the program. A list of these 20 engagements giving type of target, target range, target movement, etc., is given in Appendix A of Volume II.

Lesson Plans. The lesson plans were developed primarily to help the instructor conduct training on the device. The plans contained an instructor's guide, which set out the training time allotted, equipment needs, personnel requirements, training objectives, practical exercises, and practice monitor forms. Duties of the assistant instructor were clearly set forth.

The training objectives established for AOB sought to implant the following capabilities: respond to TC fire command, engage moving main gun targets, sense and observe main gun rounds, apply BOT to a sensed main gun round, and engage main gun multiple targets. The training activities were organized into two modules. In module 1, engagements were clustered and sequenced so that the subject would practice only one type of engagement at a time. Target features used in forming clusters are as follows:

Exercise Set 1: Target approaching, close range
Exercise Set 2: Target approaching, long range and evading
Exercise Set 3: Target moving (crossing)
Exercise Set 4: Multiple targets

In module 2, engagements were not clustered in any way; they were presented serially beginning with the first engagement on the videodisc. A copy of the lesson plans with fully stated training objectives is provided in Appendix B of Volume II.

Although a floppy diskette was requested from Perceptronics to enable subjects to practice the fire adjustment technique called Burst on Target or BOT, the diskette did not arrive prior to the start of Field Trial. Thus, although there was no way to present programmed misses to the student, limited training on the fire adjustment objective was possible using the standard diskette. In other words, the student was instructed to apply BOT procedures to his own errors (target misses).

Instructor Training Materials. These materials were used by the research staff to prepare instructors to train students with the device. In general, these materials focused on providing background information about the MK60 device, giving facts about the coming field trial, and instructing users in the steps they should employ in conducting training with the device. These materials are provided in Appendix C of Volume II.

Device Test Materials. A device pretest/posttest was specified (Melching, Campbell, and Hoffman, 1982) for development by Perceptronics, but the current training schedule of AOB personnel necessitated beginning the field trial before the specified test videodisc was completed. For this reason, a substitute device test was constructed using seven engagements from the available training material. A list of the engagements in this improvised test, showing target type, range, movement, etc., is given in Appendix D of Volume II. This test is labeled as Test Y to differentiate it from the proposed test (Test X), which was not available until Field Trial II.

Dry and Live Fire Test Materials. Through-the-sight video recording of dry fire performance was undertaken as part of the device field trial procedures. These tests required preparation of materials such as target vehicle locations and movements (direction and speed), target vehicle driver instructions, special instructions to gunners, and contrived sets of fire commands for tank commanders. Materials comprising the dry fire test as conducted on Kennedy range are given in Appendix E of Volume II.

Live fire testing required no new materials. Guidance consisted of Table VIA. A copy of that table is also given in Appendix E.

Student Questionnaire. A questionnaire was developed to gather opinions about the perceived usefulness of the device from all students who received training on the device. This questionnaire focused on matters such as how well the student liked training on the device (20 items), how realistic the device appeared (7 items), how useful the feedback was about performance that the device provided (4 items), and what recommendations he would make about amount of training time on the MK60 compared with other training devices (3 items). A copy of the AOB student questionnaire is provided in Appendix F of Volume II.

Instructor Questionnaire. This questionnaire sought similar information. Specifically it asked instructors for their opinions about problems they had while operating the MK60 (7 items), how realistic the device

appeared (7 items), how helpful the device feedback was in coaching students (4 items), and how the device compared with other devices in teaching tank gunnery (10 items). A final section asked for some demographic information (2 items). A copy of the AOB instructor questionnaire is provided in Appendix G of Volume II.

Miscellaneous Materials. Materials were prepared to assist the staff in administering tests and in informing subjects about their role in the field trial. Also prepared were forms for recording performance of students on the device during training and testing. Copies of these materials are provided in Appendix H of Volume II.

Procedure

Scheduling of Field Trial Activities. It was anticipated that the data collection activities of Field Trials I and II would overlap and, to prevent conflicts in training and testing on the MK60, a careful scheduling was essential. Thus, several weeks before the field trial of the device began, a series of conferences was held with interested U.S. Army agencies located at Fort Knox, Kentucky, the site of the field trials. Conferences were held with representatives of the Weapons Department of the Armor School (source of subjects for Study I) and with representatives of the 1st Advanced Individual Training/One Station Unit Training Brigade of Fort Knox (source of subjects for Study II). These conferences focused on matters such as which classes or companies would participate in the field trial, the dates and hours of participation, places of training, nature of support requirements, etc. Also, since there was a need for tank gunnery ranges, and an expectation that dry and live fire engagements would be videotaped, conferences were held with representatives of the Armor and Engineer Board, the Directorate of Training Developments, and the Directorate of Plans and Training. One output of these many conferences was the development of a detailed schedule of activities. This schedule set out explicit dates, places, times, events, etc., and it served to guide all participating organizations in the conduct of the field trials.

Training of Instructors. The AOB instructors who were assigned to conduct the training of students on the MK60 were first instructed about the device and the field trial by the research staff. Specifically, the instructors were trained to:

1. Maintain records of device usage.
2. Operate on the various device components.
3. Operate the device as a gunner would.
4. Help students keep records of their performance on the device.
5. Use information provided by the device to guide students in tank gunnery.

After instruction was completed, each instructor was given a set of the lesson plans that had been developed to guide the training of AOB students on

the device. He was asked to review these lesson plans prior to the time he began conducting training on the device.

Device Pretest. The improvised device test (Test Y) was administered by the research staff to each subject before any training on the device was given. The test was administered during the last hour of the initial eight hour block of conduct of fire training. Because subjects had received this training, they were instructed to use all of the conduct of fire procedures (M60A1 tank) they had learned when performing the test.

With respect to the required positions of device switches and controls when testing began, APDS-T was indexed, the turret switch was ON, and all other switches were OFF. Each student spent from 10 to 15 minutes in completing the pretest.

The following items of information were recorded for each engagement for each subject:

1. Position of main gun switch
2. Type of ammo indexed
3. Whether gunner announced IDENTIFIED before firing the first round
4. Whether gunner announced ON THE WAY before firing the first round
5. Engagement score
6. Total engagement time, in seconds
7. Number of rounds fired
8. Miss distance, in mils
9. Whether target was hit or missed

Training Design. The field trial design called for a control group of AOB students who were tested but received the normal training and two MK60 trained groups who received two different intensities of MK60 training plus testing.

Two MK60 training modules were developed to plug into the existing AOB training schedule. Module 1 was received by both the high and low intensity groups. Module 2 represented the additional practice received by the high intensity group only. Module 1 was scheduled to occur during the first four-hour block of turret trainer mounted M55 Laser instruction which was presented on the second day of AOB conduct of fire training. Each four-man crew was allowed one hour to practice on the MK60 in place of one hour of M55 Laser instruction. Thus, each MK60 trained student was to be able to practice for one hour on one of the MK60 devices. The assumption had been that as a result of this substitution, control students would receive four hours of M55 Laser training, while MK60 students would receive one hour of MK60 plus three hours of M55 Laser training. However, because of unanticipated instructor and M55 Laser shortages, students were required to rotate practice with the M55 Laser. As a result, the actual difference in training during these periods was that the MK60 students each received approximately one hour of practice on the MK60 compared to no MK60 practice for the control group, but all students received approximately two hours of practice on the M55 Laser.

Module 2 consisted of approximately 45 minutes of MK60 practice for each high intensity group student. It was administered approximately ten days after module 1, and two to three days prior to the dry fire exercise. The presentation of module 2 occurred during the time students would have normally have spent waiting to receive training on Tank Tables I through IV, which was conducted using turret trainer mounted M55 Lasers.

Specific numbers of training trials on the MK60 were not planned. However, a record was kept of the amount of MK60 practice each student received. Using the scoreboard display on the MK60, each student recorded the following information on each engagement he undertook.

1. Engagement score
2. Total engagement time, in seconds
3. Number of rounds fired
4. Average miss distance, in mils

One instructor was expected to be present during each hour of training to provide instruction and corrective feedback to the students. However, again due to unanticipated instructor shortages, for approximately 30-40 percent of the training time no Armor School instructor was present. On these occasions, research staff who were monitoring the training and who were familiar with the procedural aspects of M60A1 gunnery provided guidance and feedback to the students as necessary. Typically the students needed little guidance concerning the procedural aspects of M60A1 gunnery.

Device Posttest. The posttest (Test Y) was administered by the research staff to high intensity MK60 subjects immediately following the completion of module 2 training. Low intensity MK60 subjects and control subjects were also given the posttest at this time. The same performance data were recorded as during the pretest. Subjects used 10 to 15 minutes to complete the test.

Dry Fire Test. Each AOB class was given a dry fire test within 1 to 3 days after the device posttest. The test took place on Kennedy range at Fort Knox. The test required four instrumented M60A1 tanks with AOB instructors acting as tank commanders. Detailed information about this test is provided in Volume II of this report. Only general information is given here.

Table 1, using data from Volume II, shows the eight moving targets that were used for all AOB classes. Ammunition was announced only, not loaded or fired. A planned ninth engagement could not be completed by one of the classes due to road conditions and was consequently dropped from the analysis.

Before each engagement began, the subject was asked to lay on a calibration panel. When the fire command was given, he was directed to track (lead) the target and to "fire" when appropriate. As soon as the engagement was completed, he was asked to lay again on the calibration panel.

Table 1

AOB Dry Fire Exercise
Kennedy Range

Target	Range	Direction	Speed	Ammo	Required Lead Standard	Required Lead Optimum	Subsequent Fire Command
Jeep	400	R-L	10	SABOT	2.5	2.2	"drop 2 mils"
Jeep	400	L-R	20	HEP	7.5	13.6	"left 5, add 2 mils"
APC	1800	R-L	10	HEAT	5.0	5.0	--
APC	1800	L-R	5	HEAT	5.0	5.7	"left 2"
Jeep	600	R-L	20	SABOT	2.5	2.0	--
Jeep	600	L-R	5	SABOT	0	0	--
APC	1800	L-R	5	HEAT	5.0	5.0	--
APC	1800	L-R	15-20	HEAT	5.0	9.0	"right 5"

A videotape camera, placed in the IR sight elbow of each tank, recorded the sight picture at the time the trigger was pulled. Subjects proceeded through the test in crews of four, with each crew member tested on a different tank. All fire commands, including those for adjust fire, were prepared in advance for use by the tank commanders.

The dry fire videotapes were used to assess both time and lay error data. Time was electronically recorded on the videotape at the time of recording. The difference in seconds between the time the TC announced "Gunner" and the student gunner announced "Identified" was recorded as time to acquire. Although the TC's initial lay on target adds to this time, it was not expected to contribute to any systematic difference between groups. Time to lay was taken as the difference between the announcement of "Identified" and trigger pull. For engagements with a subsequent fire command, time to adjust was recorded as the time between the announcement of "Fire" in the TC's subsequent fire command and the time of the gunner's second trigger pull.

Lay errors were calculated by first measuring the distance between target center of mass and the gunner's aiming point, along both the X and Y dimensions, and then converting the distances to mils.

The Y distances were treated as elevation errors except for one retreating and one approaching target. For the retreating target the assumption was made that the correct aiming point should be one mil above center of mass, and for the approaching target an aiming point of one mil below center of mass was assumed correct. Elevation errors were adjusted accordingly for these two targets. Lead errors were calculated as the difference between either a standard lead or an optimum lead and the student's actual lead. Radial error was calculated as the square root of the sum of the squared lead and elevation errors. Radial errors were calculated for both standard leads and optimum leads.

Notations were made for tabulating the variety of technical problems incurred during the scoring of the videotapes of the dry fire test.

Live Fire. Live fire began on the day following the dry fire test. Tank Table VIA guided the conduct of this test, and all AOB students participated. Firing procedures were under the control of AOB instructors and range personnel, and the research staff sought to obtain performance data without interfering with on-going activities. For the first AOB class, a camera was mounted in the sight elbow of each of four tanks. Each camera videotaped the aiming point of a tank at the time the gunner fired. A hit was scored on the replay of the videotape when the aiming point was on a target, even if the actual round misses.

For the other two classes, normal AOB class Table VIA score cards were relied upon. Videotaping was suspended because of a possible safety hazard. Score cards could not be obtained for one of these classes.

Results and Discussion

AOB Students' Opinions - Questionnaire Analysis

The AOB opinion questionnaire contained four sections dealing with attitudes and experiences of students in the use of the MK60 device. The results are discussed by questionnaire section. The questionnaire was completed by 25 soldiers in the low group and 22 in the high group. A complete record of the ratings of the two groups is found in Table A-1 of Appendix A of Volume I of this report.

Section A. The 20 items in this section focused on how well the students liked training on the device. A five-point scale ranging from 1 (strongly disagree) to 5 (strongly agree) was used to obtain opinions about the device. Using the scale, students indicated the extent of their agreement with each of a set of special statements about the device. Negatively worded items were reverse scored and mean ratings calculated for each item. For the low group the mean rating for the 20 items was 3.76; for the high group the mean was 3.71. Group differences were minimal across all items. Highly rated items are shown below with their ratings.

Rating			
Low Group	High Group		Item Number and Content
4.56	4.18	12.	I tried to better my score on the MK60 each time I practiced an engagement.
4.44	4.23	1.	I liked practicing on the MK60 training device.
4.16	4.23	10.	I thought the problems on the MK60 were challenging.
4.32	4.04	15.	I had too much practice on the MK60 trainer. (reverse scored)

Section B. The seven items in this section employed a five-point scale ranging from 1 (not at all realistic) to 5 (extremely realistic) and invited subjects to evaluate the realism of the device. For the low group the mean rating of all items was 3.26; for the high group it was 2.96. In general, both groups tended to view the device as "moderately realistic." Items receiving the highest and lowest ratings are shown below.

Rating			
Low Group	High Group		Item Number and Content
3.68	3.77	21.	Switches and indicator lights
3.96	3.73	22.	Cadillac controls
2.76	2.32	25.	Sound effect of tank turret

Section C. This section contained four items. These items coincided with the four kinds of feedback the device provided to the subject after he completed an engagement. Using a five-point scale ranging from 1 (not at all helpful) to 5 (extremely helpful), subjects were asked to rate the helpfulness of each kind of feedback. The mean rating for the four items for the low group was 3.74, and for the high group it was 3.68. The item rated highest was "Engagement time" (4.24 and 4.09).

Section D. In this section subjects were asked to judge how they would allocate their training time among several training devices. The responses of the two experimental groups are shown below. Opposite each device being compared are the mean percentages for low and high groups. Due to rounding errors, the high group percentages do not add up to 100.

Percentage		
Low Group	High Group	Device
11%	11%	Willey
40%	31%	MK60
49%	60%	Turret Trainer

There is an obvious preference of the high group for the turret trainer. Low group subjects felt the same way, but to a lesser extent. Note also that these proportions reflect a desire for an increase in the proportion of MK60 practice from that used in the field trial training program.

Training Effectiveness - MK60 Pretest-Posttest Analyses

A total of 69 AOB students completed both pretest and posttest exercises with 23 students in each of the three treatment groups. MK60 performance scores were analyzed for pretest-posttest differences and for posttest differences among the three treatment groups. Means of the students' MK60 performance scores appear in Table 2.

Repeated measures ANOVA were conducted with amount of MK60 training being the between group factor, with test engagements (7) and test session

Table 2
AOB Field Trial
MK60 Average Scores for Seven Test Engagements

	Pretest[a]			Posttest[a]		
Variable	Control	Low	High	Control	Low	High
"Identified"	28%	35%	38%	68%	92%	99%
"On the Way"	32%	31%	46%	78%	92%	99%
Average Score	65.2	66.8	75.8	89.0	105.8	108.9
Average Seconds	29.5	27.2	25.5	21.7	18.2	17.1
Average Rounds	2.7	2.8	2.7	2.3	2.3	2.4
Average Miss Mils	3.3	2.9	2.3	1.9	1.8	1.6
Average Hits	84.4%	87.3%	86.2%	93.2%	94.1%	96.9%

[a]Pretest-Posttest gains are significant across groups on all variables.

(pre-post) being the two within group factors. This ANOVA procedure was repeated for seven of the nine types of MK60 performance scores. Correct operation of the main gun switch and ammo handle were not analyzed; the percent responding correctly on both pretest and posttest engagements was extremely high for both variables.

Table 3 summarizes the results of these ANOVA. Complete summary tables for these analyses appear in Appendix A to Volume I (Tables A-2 through A-8). Due to occasional device malfunctions, there were some missing data which caused the slight variation in degrees of freedom for the respective analyses.

For each of the seven measures, there was a significant pretest-posttest main effect. That is, students across all groups improved their MK60 performance from the pretest to the posttest. Only one other significant result was obtained. There was a significant main effect for treatment groups for the assessment of whether or not students remembered to say "on the way" just prior to firing. For an unknown reason the control group appeared lower on this variable on the pretest and posttest. In none of the ANOVA was there a significant group by test session interaction which would have signified differential amounts of improvement on the MK60.

Repeated measures analyses of covariance (ANOCOVA) were also conducted on the seven posttest engagements with the seven pretest engagements as covariates. Again, the ANOCOVA procedure was repeated for each of the seven MK60 performance scores (see Table 4, and in Appendix A, Tables A-9 through

Table 3

ANOVA Summary (F values)
MK60 Pretest-Posttest

	Source		
Variable	Group	Pre-Post	Group X Pre-Post
"Identified"	4.33**	109.59***	1.73
"On the way"	2.91*	122.29***	.78
Score	2.70*	62.71***	.30
Seconds	3.02*	69.07***	.14
Rounds	.17	17.50***	.51
Miss Mils	2.47*	25.89***	1.03
Hits	.57	22.45***	.36

* $p < .10$

** $p < .05$

*** $p < .01$

Table 4

ANOCOVA Summary
MK60 Posttest

	Variable						
	"Identified"	"On the Way"	Score	Seconds	Rounds	Miss mils	Hits
F:	10.13***	6.06***	3.18**	2.82*	.80	.19	1.18

* $p < .10$

** $p < .05$

*** $p < .01$

A-15). Table 5 presents the posttest means adjusted by the pretest covariate. The ANOCOVA revealed significant ($p < .05$) group differences for three of the performance scores: announcing "Identified," announcing "On the way," and engagement score. Recall that engagement score is calculated as a function of time, rounds used and hit accuracy. Seconds per engagement was significant at $p < .10$. For these scores, MK60 trained groups improved more than regularly trained groups.

Table 5

MK60 Posttest Scores Adjusted for Pretest Performance

Variable	Control	Low	High
"Identified"[a]	68%	91%	99%
"On the way"[a]	77%	93%	99%
Device Score[b]	89.7	106.2	108.0
Seconds[c]	21.5	18.2	17.3
Rounds	2.3	2.3	2.5
Miss Mils	1.9	1.8	1.6
Hits	93.2%	94.1%	96.9%

[a] Group effect significant at $p < .01$.

[b] Group effect significant at $p < .05$. Highest possible score is 206.43.

[c] Group effect significant at $p < .10$.

In addition to these univariate ANOVA on the seven engagements, means were calculated for each student for their posttest engagement scores, seconds, rounds used, miss mils and hits across the seven engagements. The procedure used to calculate means for students with missing data is described below under Dry Fire Analysis. These five averages were then used as the criterion set in a multivariate analysis of variance (MANOVA). A significant group difference was obtained with Wilk's Lambda value of .62 significant at $p < .01$ ($F = 3.33$, $df = 10, 124$). Univariate ANOVA's on the mean posttest scores were significant for engagement scores ($F = 3.77$, $p < .05$) and seconds to complete the engagement ($F = 4.32$, $p < .05$).

This pattern of results clearly suggests an improvement in MK60 engagement scores occurred from the pretest to the posttest. Furthermore, it appears that the increase may be attributable to speed of achieving a hit. All groups have a high rate of hits; however, the MK60 trained group achieved hits faster on the posttest.

Because the MK60 training modules were designed around scheduled time rather than number of trials, the number of MK60 engagements completed by the MK60 trained students varied. Table 6 presents statistics related to the amount of practice received.

An alternative method for examining the effect of MK60 practice on the MK60 posttest scores is to evaluate the correlations between number of practice engagements and average posttest scores. These correlations appear in Table 7. Parallel to the conclusions of the ANOVA and ANCOVA, number of practice engagements is significantly related to engagement score and seconds. Furthermore, average hits on the posttest is also significantly related to amount of practice. Because training was scheduled by time, students who performed well (e.g., faster) on the pretest may have been able to put in more practice trials. Therefore, partial correlations between posttest score and amount of training were computed to statistically remove pretest ability. These also appear in Table 7. With pretest score held constant, amount of training accounts for approximately six to seven percent of the variance in posttest engagement score and seconds. The relationship between hits and amount of training is not statistically significant with pretest hits held constant.

Table 6

Number of Practice Engagements
MK60 Trained Students

Group	Mean	Standard Deviation	Range
High Intensity	66.04	7.95	31
Low Intensity	33.91	6.64	26

Table 7

Correlation between Number of Practice Engagements and Average MK60 Posttest Scores

	Engagement Score	Seconds	Rounds	Miss Mils	Hits
Correlation	.30**	-.33**	.07	-.12	.25*
Partial Correlation (Pretest Score held constant.)	.26*	-.27*	.07	-.02	.24

* $p < .05$.

** $p < .01$.

MK60 Scores During Training. Tables A-16 and A-17 of Appendix A to this volume display means and standard deviations for MK60 engagement score, seconds, rounds and miss mils for each repetition of each of the 20 training engagements for training modules 1 and 2. The general pattern of improved performance is apparent. Also apparent is the ambiguity of the engagement score. That is, each engagement was assigned a maximum possible score based on a number of parameters related to the difficulty of the engagement. More difficult problems were to have higher maximum point values. Because of this adjustment, the average number of points received should be approximately the same across all engagements. Based on the performances recorded during the practice sessions, the maximum possible points do not seem to reflect target difficulty. For example, there are three 260 point engagements for the high intensity students during their first repetition of module 2, but the average scores for these engagements ranged from 26.7 to 115.3. Average scores for three 150 point engagements ranged from 35.8 to 66.0. Average scores for two 460 point engagements were 269.0 and 235.4. Both the discrepancy of score averages between engagements of equal maximum value and the discrepancy between engagements of different maximum value seem to question the assignment of maximum point values.

The record of performance scores is also relevant to the "bonus engagement" concept which was to be incorporated into the MK60. A "bonus engagement" was to be presented at the end of a set of practice engagements if a student achieved an average of 90% of the maximum possible score. Although the bonus problem was not accessible for technical reasons on the tested version of the MK60, even in the high intensity group students were far from achieving that 90% average. None of the practice score averages approached the 90% criterion. However, this did not affect student motivation. As identified in the questionnaire results, students were highly motivated to perform well and improve on the MK60.

Transfer of Training - Dry Fire Analysis

AOB students were scored on eight dry fire engagements. Of the 69 students who participated in the field trial, six were not administered the dry fire exercises because adverse weather conditions reduced visibility below the operating capacity of the videocameras. Of the 63 who participated in the dry fire exercise, only one person had complete time and lay error data for all engagements. A complete description of the causes for the missing data appears as Appendix B to Volume I.

Because of the frequency of missing data a repeated measures ANOVA using engagements as the within group factor was inappropriate. Instead, average time and lay errors were calculated for each student. Because no assumption could be made about item difficulty, a simple mean of the scored engagements was inappropriate. If a relatively difficult engagement was missing, the mean of the others would be too high. Similarly, if a relatively easy engagement was missing, the mean of the others would be too low. Therefore, the Yates procedure, discussed by Kirk (1968) was used to estimate missing data points for each of the dry fire variables. The effect of the procedure is to provide estimates for missing data points which are a function of the student's performance on completed engagements and the difficulty of the engagement relative to the other engagements. The procedure requires initial

guesses for each missing data point. These guesses were calculated by 1) calculating standardized scores from all non-missing data points, 2) for each student, averaging the standardized score across all non-missing engagements, 3) for each student, replacing missing data with his mean standardized score, and 4) converting the matrix back to unstandardized scores. The Yates formula then estimates only one data point at a time using, in addition to the non-missing points, the initial z-score derived guesses throughout the data matrix except for the one point being estimated. The Yates formula is sequentially applied to each missing point. Thus, the first time through the matrix, some Yates formula estimates are based on z-score derived guesses and estimates previously calculated by the Yates formula. The application of the Yates formula must be cycled throughout the matrix until the estimates achieve stability. For the dry fire data, this procedure was repeated separately for each of the seven first round variables and six second round variables. For each of these thirteen variables the Yates formula was cycled through the data matrix five times.

Finally, the data matrix with missing data estimates was used to calculate mean performance for each student. Mean performance of the seven first round variables was based on all eight engagements and mean performance of the six second round variables was based on the four engagements with subsequent fire commands. For lay error scores, mean performance was calculated as the mean of the absolute values for each lay error.

Means for the control, low and high treatment groups for these thirteen dry fire variables appear in Table 8. Multivariate analysis of variance was conducted first using the time variables, the first and second round elevation errors, and the first and second round lead errors based on standard lead policy, and secondly using the time and elevation data along with lead errors calculated from optimum required leads. Neither MANOVA obtained a significant group effect. For the first MANOVA, Wilk's Lambda was .76 (F = 1.14, df = 14, 108, n.s.); for the second MANOVA, Wilk's Lambda was .72 (F = 1.38, df = 14, 108, n.s.). Univariate ANOVA were also conducted. Table 9 summarizes these results. While the MANOVA are not statistically significant, two of the ANOVA suggest group differences in use of first round optimum lead and time to adjust. For time to adjust the MK60 trained groups appear faster (3.19 and 2.91 seconds for the high and low groups) than the control group (3.98 seconds). For optimum lead, the high intensity MK60 group is essentially the same as the control group (4.19 and 4.15 mils) while the low intensity group appears somewhat more accurate (3.77 mils).

Reliability of the Dry Fire Performance Measures. To estimate the reliability of the dry fire exercise scores, intercorrelations among the scores from each separate engagement were calculated. The correlations were calculated on the data set prior to the insertion of estimates for missing data, with each correlation based on the number of non-missing observation on both variables of the correlation. Inclusion of the missing data estimates would have stabilized the score for each subject with missing data and consequently increased the apparent relations among the observations. A set of intercorrelations was calculated for each of the nine dry fire variables used in the preceding MANOVA. For each of the nine the average intercorrelation was computed using Fisher's r to z transformation. The average intercorrelations are as follows: time to acquire, r = .18; time to lay, r = .40; first

Table 8

AOB Field Trial
Dry-Fire Exercise Performance

Variable		Control (n=21)		Low (n=21)		High (n=21)		Total (n=63)	
		Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Time to Acquire[a]		9.25	9.99	6.54	4.03	5.85	2.56	7.21	6.46
Time to Lay[a]		7.12	2.57	6.35	1.89	6.74	2.37	6.73	2.28
1st Round Lead Error[b]	Standard	2.21	.69	1.82	.72	2.18	.84	2.07	.76
	Optimum	4.15	.55	3.77	.49	4.19	.68	4.04	.60
1st Round Elevation Error[b]		.43	.24	.46	.23	.41	.15	.43	.21
1st Round Radial Error[b]	Standard	2.52	.68	2.27	.78	2.56	.86	2.56	.77
	Optimum	4.46	.76	4.30	.72	4.59	.79	4.45	.75
Time to Adjust[a]		3.98	1.59	2.91	1.16	3.19	1.61	3.36	1.51
2nd Round Lead Error[b]	Standard	4.03	1.05	3.90	1.01	3.85	1.87	3.93	1.07
	Optimum	6.47	1.02	6.31	1.04	6.24	1.22	6.34	1.08
2nd Round Elevation Error[b]		1.04	.15	1.02	.16	.95	.13	1.00	.15
2nd Round Radial Error[b]	Standard	4.57	1.13	4.70	1.27	4.49	1.50	4.59	1.32
	Optimum	6.94	1.37	7.00	1.34	6.77	1.50	6.91	1.31

[a]Seconds

[b]Mils

round lead error (both optimum and standard), $\underline{r}$ = .16; elevation error, $\underline{r}$ = .07; time to adjust, $\underline{r}$ = .49; second round lead error (both optimum and standard), $\underline{r}$ = -.03; second round elevation error, $\underline{r}$ = .00. From these average intercorrelations, the Spearman-Brown formula was used to estimate internal consistency reliability from eight engagements. These reliability estimates are overestimates to the extent that students were not able to be assessed on all eight engagements. Estimates for time to lay (r_{ii} = .84) and time to adjust (r_{ii} = .88) were respectable. The estimate for time to acquire (r_{ii} = .63) was lower, due to differences partially attributable to variation in the technique of the TC issuing the five commands which was observed during scoring of the video tapes. However, it may be viewed as serviceable. The reliability estimate for first round lead errors was .61, again, marginal but serviceable. The remaining variables received reliability estimates all less than .50.

Table 9

One-Way ANOVA
Dry Fire Variables

Criterion Variable	MS Group	MS Error	F
Time to Acquire	67.96	40.84	1.66
Time to Lay	3.12	5.25	.59
Time to Adjust	6.48	2.15	3.01*
First Round:			
Standard Lead Error	.95	.56	1.69
Optimum Lead Error	1.12	.34	3.30**
Elevation Error	.01	.04	.22
Second Round:			
Standard Lead Error	.18	1.17	.15
Optimum Lead Error	.28	1.20	.23
Elevation Error	.04	.02	2.07

* $p < .10$

** $p < .05$

Simulated Test Validity for Dry Fire Variables

Correlations between MK60 pretest and posttest engagement score, seconds, rounds, miss mils and hits and the thirteen dry fire variables are presented in Table A-18 in Appendix A to this volume. Of the 130 correlations, only two are statistically significant at $p < .05$, a number that would be expected by chance without any underlying relationships. Pretest average miss mils correlates .21 and .22 with standard based and optimum based second round radial errors, respectively. Thus, MK60 scores do not appear to have validity for predicting M60A1 dry fire scores for AOB students.

Correlations were also calculated between number of MK60 engagements practiced and dry fire performance. These are also in Table A-18 in Appendix A. One of the thirteen correlations was significant at $p < .05$. Number of training engagements correlated with time to adjust to the subsequent fire command -.21. Recall that MK60 training did not include subsequent fire command practice.

MK60 Reliability. Such poor predictive validity results could be indicative of poor reliability. A frequently used method of estimating test reliability is to administer the test on two different occasions to the same set of subjects and calculate the correlation between the two sets of scores. This test-retest method of assessing reliability assumes that no significant events have intervened between testing occasions to alter the relative order of tested subjects. For the MK60 pretest-posttest data, a significant event did occur, namely MK60 training. Furthermore, subjects received different amounts of training so the expectation was to observe a shift in relative order from pretest to posttest. However, if amount of training was statistically held constant, and the assumption was made that no other conditions occurred to cause a change in relative order of the subjects, the correlation between pretest and posttest performance would be indicative of the stability of the MK60 seven engagement test. These partial correlations along with the respective zero-order correlations appear in Table 10.

Table 10

Correlations between MK60
Pretest and Posttest Scores

	Engagement Score	Seconds	Rounds	Miss Mils	Hits
Correlation	.22**	-.40**	.00	-.45	.13*
Partial Correlation with amount of training held constant.	.17*	-.35*	.00	-.44	.12

* $p < .05$.

** $p < .01$.

The pretest-posttest partial correlations are significant only for seconds and miss mils and these certainly are not large. It may be that there is considerable difference in gunnery aptitude among the subjects which is not measured by the MK60 pretest but which does affect the relative amount of learning on the device. On the other hand, the MK60 test may have low test-retest reliability. Thus, strong predictive validity would not be expected.

Transfer of Training - AOB Table VI Main Gun Performance

For the first AOB class, through the sight videocameras recorded sight pictures at the time of firing. Only 18 of the 23 students were videotaped, because of technical difficulties with the cameras. A total of 74 targets (all stationary) were scoreable; only two misses were observed. No further analyses were conducted.

Score cards were unattainable for Table VI of the second AOB class. They were obtained for the third class, but because of idiosyncrasies in the TCs' methods of recording, the data were inconsistent and in some cases uninterpretable. For example, some engagements allowed the student more than one round to hit a target. The score card might simply be marked "yes", without an indication as to whether the hit was achieved on the first, second or third round, or if it was hit more than once. No analyses were conducted.

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FIELD TRIAL II

The purpose of Field Trial II was to assess the MK60 training potential for Basic Armor Training.

Method

Subjects

The subjects for Field Trial II came from four Basic Armor Training (BAT) companies of the 1st Advanced Individual Training/One Station Unit Training Brigade, Fort Knox, Kentucky. Participating companies will be designated A, B, C and D. All subjects had undergone Conduct of Fire I and II training (four hours each) for the M60A1 tank before they undertook testing or training.

Before subjects were selected from a company for inclusion in the field trial, it was determined that the scheduling of testing and training would be facilitated if all members of a group of subjects were selected from the same platoon. Three groups (one control and two MK60 trained) were needed from each company, each of which had four or five platoons. Again, because of the tightness of scheduling, testing and training, it was necessary to assign a particular platoon as the subject pool for the control group. The platoon to supply the pool for the low group was randomly selected from two of the remaining platoons which matched scheduling requirements. The platoon to supply the pool for the high group was similarly selected. After platoons were selected, a table of random numbers was used to select students to serve as subjects. Names of students were arranged alphabetically in each platoon and then numbered from 1 to n. The first ten numbers picked from the table of random numbers determined which persons were to serve as subjects in a group. This procedure was followed for each group. Ten persons were selected initially in the event some subjects failed to appear for testing or training. Thus, a total of 30 soldiers were chosen from each participating company at the beginning of the study; for all four companies the total was 120 subjects.

Training and Testing Materials

Except for two ability pretests, the bulk of the training and testing materials used in Field Trial II were quite similar to those used in Field Trial I. The nature of the differences in each item is described below, along with consideration of the ability pretests.

Ability Pretests. It has been conjectured (Campbell & Black, 1982) that training in tank gunnery could be facilitated if a reliable means could be found for identifying, prior to training, those persons who, after training, become expert gunners. Thus, one approach to identifying such persons would be to collect scores of subjects on a special test taken before training and to correlate them with criterion task scores (firing the tank main gun) after

training. That approach was employed in Field Trial II. Two tests were employed. Both tests involved tasks that were similar to those performed by a tank gunner: target tracking and target detection. Called ability pretests, they were described in an earlier report (Melching & Hoffman, 1982). Verbatim copies of instructions that were tape recorded for presentation to subjects during administration of the tests, along with copies of the visual stimuli used in the tracking task, are provided in Appendix I of Volume II of this report. Ability pretests were administered during the sixth week of soldiers BAT training.

Device Training Materials

As noted in Field Trial I, sets of tank gunnery engagements for use on the MK60 were proposed (Melching, Campbell, & Hoffman, 1982); they were to guide the preparation of the videodiscs to be used in the field trials. However, production of these videodiscs was delayed, and to permit the research to proceed, Perceptronics provided a single videodisc using available target scenes. While this videodisc contained 20 main gun and six coax engagement scenes, accompanying software problems prevented access to the coax engagements. Thus, only 20 main gun engagements were available for training in Field Trial II.

Before Field Trial II started, a floppy diskette was received from Perceptronics that would permit fire adjustment training. This diskette used the 20 main gun engagements as before. By providing incorrect trajectory parameters, it caused a correctly laid round to be represented by the MK60 as a miss. In order to achieve a hit, the student gunner had to practice the fire adjustment technique called "Burst on Target" or BOT. The subjects of Field Trial II, therefore, used this diskette in their fire adjustment practice. In all other respects, the device training materials were like those used in Field Trial I.

Lesson Plans. Beyond minor format differences, the main area differentiating the lesson plans of the two studies was in fire adjustment training. Since the special floppy diskette developed to permit fire adjustment training was available when Field Trial II began, the objectives and practice activities of the Field Trial II lesson plans were modified to reflect that change. The training objectives established for BAT focused on these capabilities: respond to TC fire command, engage moving main gun targets, sense and observe main gun rounds, apply BOT to a sensed main gun round, adjust fire according to subsequent fire command, and engage main gun multiple targets.

As in Field Trial I, the training activities were organized into two modules. In module 1, engagements were clustered and sequenced so that the subjects would practice only one type of engagement at a time. The clusters were the same as those described in Field Trial I. In module 2, the engagements were not clustered in any way; they were presented serially beginning with the first engagement.

The lesson plans in Field Trial II provided for practice in performing BOT in engagements in which programmed misses were provided. Subjects also

received training in responding to subsequent TC fire commands. The BAT lesson plans are included in Appendix J of Volume II.

Instructor Training Materials. These materials were like those used in Field Trial I except that BAT instructors were given information that enabled them to program the device for new or different sets of engagements. These materials appear in Appendix K of Volume II.

Device Test Materials. In addition to Test Y, which was constructed from the training engagements, another test (Test X) was specified (Melching, Campbell, & Hoffman, 1982) for development by Perceptronics. Text X was to employ target scenes not used in training. Its pretest form was to contain 2 manipulation exercise items, 2 practice engagements, and 10 test engagements. Its posttest was to include the 10 test engagements of the pretest, plus an additional 10 test engagements.

Certain features of the proposed (and actual) Test X warrant comment. At the time the test specifications were developed, it was assumed that subjects would not have had any conduct of fire training before they undertook the pretest form of Test X. So that subjects would not be penalized by this lack of training, two manipulation exercises were provided at the front of the pretest. Their purpose was to give subjects manipulation practice before they attempted to engage targets on the device. Unfortunately, the floppy diskette that accompanied the test videodisc could not access the practice exercises; thus, none could be used. However, since subjects had actually received conduct of fire training before the test, the inability to practice the manipulation exercise may not have been important.

Another feature of the proposed test was the inclusion of practice engagements. The first six engagements were stationary targets, and of these, the first one was intended for practice only. The next six engagements were moving targets, and the first of these was intended for practice. However, because several of the subsequent engagements could not be accessed, it was necessary to employ the two practice engagements as test items.

A final feature relates to indexing ammunition. Again, assuming that subjects would not have had conduct of fire training before Test X, the pretest was deliberately planned so that ammunition would not need to be indexed. While this feature would not normally be desired, it was operative in the actual pretest, i.e., the same ammunition was required for each engagement.

Because of various problems, Perceptronics was unable to satisfy certain of the original specifications. Thus, using the materials that Perceptronics provided, the staff decided to place the first ten engagements in the pretest. All were main gun targets (6 stationary, 4 moving). Of the remaining engagements that had been specified, only seven could be accessed by the floppy diskette. These too were all main gun targets (4 stationary, 3 moving). All were placed in the posttest. A list of the engagements in Test X in terms of types of target, target range, target movement, etc., is given in Appendix D of Volume II.

Dry and Live Fire Tests. The dry fire test materials prepared for Field Trial II differed from those in Field Trial I in one important respect. While each AOB class in Field Trial I used the same range (Kennedy), two different ranges were used in Field Trial II. One company used Donnelly range; the remaining three used Boydston range. Since the possible location, speed, and direction of moving targets are unique to each range, one BAT company experienced different target conditions from the other companies. The specific nature of these differences will be discussed later in the Procedure section of this report. Materials that were used to guide the BAT dry fire testing are provided in Appendix L of Volume II. This appendix also contains a copy of Table VIA. It was the source of guidance for obtaining live fire data.

Student Questionnaire. This questionnaire was like that used in Field Trial I except that BAT students were not asked to judge how their training time might be best divided among various training devices. Their opinions were sought on how well they liked training on the device (20 items), how realistic the device seemed (7 items), and how useful were the various kinds of performance feedback provided by the device (4 items). A copy of the BAT student questionnaire is found in Appendix M of Volume II.

Instructor Questionnaire. This questionnaire asked BAT instructors to give their opinions on problems (e.g., inserting components such as the floppy diskette) they may have experienced when operating the MK60 (9 items), how realistic the device appeared (7 items), how useful the device feedback was in coaching students (4 items), and how the device compared with other devices in teaching tank gunnery (10 items). A final section asked for some demographic information (2 items). A copy of the BAT instructor questionnaire is found in Appendix N of Volume II.

Miscellaneous Materials. These materials consisted of those mentioned in Study I, plus new materials. The new materials consisted of a score sheet for the ability pretests, and pretest/posttest record forms for Test X. Copies of all these materials are provided in Appendix H of Volume II.

Procedure

Schedule of Field Trial Activities. The need for careful scheduling of activities was described in Field Trial I. The requirement to adhere to this schedule continued in Field Trial II. Of considerable importance in the scheduling was the decision to keep all five MK60 devices in the same location during both studies. This enabled groups to complete testing and training on the devices with a minimum of delays.

Training of Instructors. Five BAT instructors were assigned to conduct the training of all BAT students on the MK60. They were first instructed about the device and its evaluation by the research staff. The instructors were trained to:

1. Maintain records of device usage.
2. Operate the various device components.
3. Operate the device as a gunner would.
4. Reprogram the device to present different engagements.
5. Keep records of student performance on the device.
6. Use information provided by the device to guide students in tank gunnery.

After instruction was completed, each instructor was given a set of the lesson plans that had been developed to guide the training of BAT students on the device. He was asked to review these lesson plans prior to the time he began conducting training on the device.

Device Pretests. Each BAT subject was given two device pretests by the research staff. The improvised Test Y was administered first, followed by the pretest form of Test X. The pretests were administered during week 13 of the BAT schedule, one week following conduct of fire classes I and II. Because subjects had undergone conduct of fire training for the M60A1 tank in their regular training, they were instructed to use all the procedures learned in that training while taking the MK60 pretests.

With respect to the required positions of device switches and controls when testing began, APDS-T was indexed, the turret switch was ON, and all other switches were OFF. Test X was administered to a subject as soon as Test Y was completed. No new instructions were given other than to tell the subject that the engagements were shorter in duration. Each subject spent 20 to 25 minutes in completing both pretests.

The following items of information were recorded for each engagement on both tests for each subject:

1. Position of main gun switch
2. Type of ammo indexed
3. Whether gunner announced IDENTIFIED before firing the first round
4. Whether gunner announced ON THE WAY before firing the first round
5. Engagement score
6. Total engagement time, in seconds
7. Number of rounds fired
8. Miss distance, in mils
9. Whether target was hit or missed

Training Design. For Field Trial II as well as Field Trial I, the evaluation concept called for two levels of MK60 training to be substituted for a portion of M55 Laser training. Again, two MK60 training modules were prepared, module 1 to be administered to both the high and low intensity MK60 trained groups and module 2 to be administered to only the high intensity group.

Module 1 training on the MK60 occurred during week 10 of BAT training. It was substituted for approximately eight hours of the time normally devoted to training on Tank Tables I, II and III (day) using the M55 Laser mounted on turret trainers. On any one training day, only subjects from the low intensity or from the high intensity condition appeared. They were first

administered the MK60 pretest. That procedure lasted approximately one hour. The remaining seven hours were devoted to MK60 training. Training was usually conducted on four MK60 with 2 to 3 students assigned to each device. Occasionally only three devices were available for training because of device malfunctions. Neither exact training times nor specific numbers of training trials on the device were planned. Students typically spent 2.5 to 3 hours on the MK60.

All subjects began training on the device by practicing on the first set of exercises of module 1. A BAT instructor was present at each device and he provided instruction and corrective feedback to each subject. Subjects rotated on the device; while one practiced the engagements, another assisted the instructor in recording the various performance scores provided by the device. All subjects observed the performance of the gunner and listened to the feedback provided by the instructor.

Using the scoreboard display on the device, a subject who was not acting as gunner helped the instructor record the following information about each engagement:

1. Engagement score
2. Total engagement time, in seconds
3. Number of rounds fired
4. Miss distance, in mils

Subjects who were assigned to the high intensity condition of the study returned 15 days later and undertook module 2 training. Module 2 training was scheduled for five hours and occurred immediately after students had received their .22 cal Brewster exercises. Only two devices were available for training because two others were used for testing. With attrition reducing the number of students to about eight per group, each student received approximately one hour of training. Subjects proceeded through the entire set of main gun engagements sequentially, with a special emphasis placed on speed. Again, BAT instructors were present and records were completed indicating practice scores for each engagement.

Device Posttests. The improvised Test Y and the posttest form of Test X were administered by the research staff to high intensity MK60 trained subjects immediately following the completion of module 2 training. Low intensity subjects and control subjects were also given the two posttests on the same day after they had completed their .22 cal Brewster exercises. The same performance data were recorded as during the pretests. Subjects used 20 to 25 minutes to complete the two tests.

Dry Fire Test. Each BAT company was given a dry fire test within 1 or 2 days following the device posttests. The test took place on Donnelly range, Fort Knox, for one company, and at Boydston range for the other three companies. The test required four instrumented M60A1 tanks. The four BAT instructors who conducted training on the MK60 served as tank commanders. Detailed information about this test is provided in Volume II of this report. Only information that highlights the differences in the tests is given here.

The anticipated set of target conditions for the three companies scheduled to fire on Boydston range is shown in Table 11. Due to uncontrolled events, each company actually undertook a different dry fire test. Company "A" for example, dry fired only engagements 1, 3, 4, 6, 7, and 8 because the vehicle to provide engagements 2 and 5 was unavailable, and the mover was not used in order to save administration time because of impending darkness. Company "C" was able to dry fire all engagements except 2 and 5. The third company ("D") was the only one able to dry fire all of the planned engagements.

Table 11

BAT Dry Fire Exercise
Boydston Range

Target	Range	Direction	Speed	Ammo	Required Lead Standard	Required Lead Optimum	Subsequent Fire Command
Jeep	400	R-L	20	SABOT	2.5	7.0	"drop 2 mils"
Truck	1600	L-R	5	SABOT	2.5	2.4	--
Jeep	600	Away	5	HEAT	0.0	0.0	--
Jeep	800	R-L	10	HEP	7.5	7.2	"left 2, add 2 mils
Truck	1600	R-L	10	HEAT	5.0	3.3	"right 2
Jeep	800	L-R	10	SABOT	2.5	3.3	--
Jeep	600	Toward	5	HEP	0.0	0.0	--
Jeep	400	R-L	20	HEAT	5.0	9.0	--
Mover	900	L-R	10-15	HEAT	5.0	2.8	"right 2"
Mover	700	R-L	10-15	SABOT	2.5	4.5	"add 2 mils"

The set of dry fire engagements scored for Company "B" on Donnelly range is shown in Table 12. The eight moving targets were at ranges of 400 to 1600 meters and speeds of 5 to 20 mph. Two APC's were used for target vehicles.

Recording and scoring procedures for the dry fire exercise were identical with the procedures used in Field Trial.

Table 12

BAT Dry Fire Exercise
Donnelly Range

Target	Range	Direction	Speed	Ammo	Required Lead Standard	Required Lead Optimum	Subsequent Fire Command
APC	600	R-L	20	HEAT	5	7.7	--
APC	1200	R-L	5	HEP	7.5	4.4	"drop 2 mils"
APC	1300	R-L	10	HEAT	5.0	4.5	"right 2"
APC	400	L-R	10	SABOT	2.5	3.5	"drop 2 mils"
APC	1300	L-R	20	SABOT	2.5	6.3	--
APC	1100	L-R	10	HEP	7.5	6.9	--
APC	400	Toward	5	HEAT	0.0	0.0	"left 5 mils"
APC	1500	R-L	10	SABOT	2.5	3.3	--

Table VI Main Gun Live Fire

Each company conducted the Table VI main gun exercise within the guidelines prescribed by the BAT program of instruction. Each student fired six or seven main gun rounds at targets ranging from 900 to 1600 meters. Two companies included a moving target engagement.

Scoring was accomplished by collaboration of company and research staff for two of the companies. Research staff alone conducted the scoring for the other two companies. Thus, from two to five persons were involved in scoring main gun hits and misses.

Table VI was conducted one day after dry fire for three of the BAT companies. For one of the companies ("A"), dry fire and live fire were scheduled to occur the same day, and because of range use conflicts, the dry fire had to be conducted late in the day after live fire was completed.

Results and Discussion

BAT Students' Opinions - Questionnaire Analysis

This questionnaire contained three sections dealing with attitudes and experiences of students in the use of the MK60 device. The results of this

evaluation are discussed by questionnaire section. The questionnaire was completed by 35 students in the low group and 35 students in the high group. A complete record of the ratings of the two groups is found in Table A-19 in Appendix A of Volume I of this report.

Section A. The 20 items in this section focused on how well the students liked training on the device. A five-point scale was used, and subjects indicated their extent of agreement (1, strongly disagree; 5, strongly agree) with statements about the device. Negatively worded items were reversed scored and mean ratings were computed. For the low group the mean rating for the 20 items was 4.00; for the high group it was 4.09. A 4.0 average response on a five-point scale is generally indicative of strong positive feelings. Items with particularly positive ratings were:

Rating		
Low Group	High Group	Item Number and Content
4.74	4.77	12. I tried to better my score on the MK60 each time I practiced an engagement.
4.66	4.77	1. I liked practicing on the MK60 training device.
4.80	4.03	15. I had too much practice on the MK60 trainer. (reverse scored)
4.49	4.26	10. I thought the problems on the MK60 were challenging.

The item showing the greatest discrepancy between low and high groups was number 15. Both groups tended to disagree with the statement that they had too much practice on the device, but the low group disagreed more strongly. Since both groups obviously liked the device (Item 1), but the low group had access to the device only about half as much as did the high group, the stronger feeling of the low group about amount of practice is not unexpected.

The only item with a non-positive response was "I had trouble finding the target" with mean ratings of 2.89 and 3.09 (reverse scored) for the low and high groups, respectively.

Section B. The seven items in this section employed a five-point scale and asked subjects to evaluate the realism of the device (1, not at all realistic to 5, extremely realistic). For the low group the mean rating of all items was 3.54; for the high group it was 3.61. Thus, both groups tended to view the device as midway between "moderately realistic" and "very realistic." Items receiving the highest and lowest ratings for the two groups are shown below.

Rating		
Low Group	High Group	Item Number and Content
4.11	4.14	27. Sound of fire commands
4.03	4.29	22. Cadillac controls
2.54	2.94	25. Sound effects of tank turret

Section C. This section contained four items. They coincided with the four kinds of feedback the device provided after each engagement. Using a five-point scale (1, not at all helpful; 5, extremely helpful), subjects were asked to rate the helpfulness of each kind of feedback. The mean rating for each item for both groups is shown below.

Rating		
Low Group	High Group	Item Number and Content
3.89	4.06	28. Engagement score
4.09	4.29	29. Engagement time
3.94	3.77	30. Number of rounds used
4.09	4.06	31. Miss distance in mils

The mean rating of all items for the low group was 4.00; for the high group it was 4.04. In general, then, both groups viewed the device feedback as "very helpful."

Training Effectiveness - MK60 Pretest-Posttest Analysis

Three categories of engagements were used in MK60 testing: (1) seven engagements included in training and both pretest and posttest, (2) ten engagements included in pretest and posttest and not used for training and (3) seven engagements included only in the posttest. The first set of items was selected from the training videodisc; the others were from the test disc. Separate analyses were conducted for each category of engagements. Analysis of the first set of test engagements provides an indication of how practice on specific engagements improves performance on those engagements. Analysis of the second set of test engagements provides an indication of how practice improves performance on non-trained engagements. The final set of problems provided a novel set of engagements for examining between group differences. The following analyses were conducted on the 104 students completing the field trial through the posttest phase (control - 36; low group - 35; high group - 33). Degrees of freedom vary slightly because of missing data due to infrequent device malfunctions.

Analysis of Test and Training Engagements. The seven training items included in the pretest and posttest were the same ones used for testing in Field Trial I. Just as for Field Trial I, repeated measures ANOVA with

training treatment as the between-group factor and test session and engagements as the within-subject factors were computed for announcing "identified," announcing "on the way," engagement score, seconds, rounds used, miss mils, and hits. Complete ANOVA tables appear in Appendix A to this Volume as Tables A-20 through A-26. Means appear in Table 13. A summary of all of the ANOVA appears in Table 14. All seven variables exhibit significant pretest-posttest main effects indicating improvement in MK60 performance for all students. In addition for engagement score and seconds, there is a significant test by group interaction indicating differential improvement in performance. Engagement score gains were 39.4, 57.0 and 82.4 and time gains, in seconds, were 13.5, 16.3, and 22.3 for the control, low and high groups, respectively. This is strong evidence for the effects of practice on performance of practiced items.

Table 13

OSUT Field Trial
MK60 Mean Scores for Seven Test
and Training Engagements

	Pretest[a]			Posttest[a]		
Variable	Control	Low	High	Control	Low	High
"Identified"	65%	79%	75%	97%	99%	99%
"On the way"	75%	80%	90%	97%	97%	100%
Engagement Score[b]	46.6	49.4	42.6	86.0	106.4	125.0
Seconds[b]	34.9	33.5	36.5	21.4	17.2	14.2
Rounds	2.9	2.8	2.8	2.3	2.3	2.2
Miss Mils	3.8	3.1	3.5	2.1	1.7	1.6
Hits[c]	74.4%	79.4%	69.7%	93.6%	96.8%	96.1%

[a]Pretest-Posttest differences are significant across all groups for all variables.

[b]Test X Group interaction is significant at $p < .01$.

[c]Test X Group interaction is significant at $p < .10$.

Table 14

ANOVA Summary (F values)
Seven Test and Training Engagements

	Source		
Variable	Group	Pre-Post	Group X Pre-Post
"Identified"	1.38	55.65***	1.09
"On the way"	4.27**	35.56***	1.76
Score	7.09***	477.00***	20.83***
Seconds	2.89*	428.52***	9.68***
Rounds	.41	45.13***	.14
Miss Mils	2.39*	73.02***	.45
Hits	1.48	117.65***	2.84

* $p < .10$

** $p < .05$

*** $p < .01$

ANOCOVA were also conducted on these seven posttest engagements covarying on the seven pretest engagements. Complete ANOCOVA tables are presented in Appendix A as Tables A-27 to A-33. A summary of these analyses appears in Table 15 and the adjusted means are presented in Table 16. Group effects were significant at $p < .05$ for engagement score, seconds and announcing "on the way," and at $p < .10$ for miss mils and hits. Again, this is evidence that greater practice leads to greater improvement.

Pretest-Posttest Only Engagements The ten engagements from the test videodisc which were administered during the pretest and posttest were analyzed in the same way as the previous analysis. That is, repeated measures ANOVA and ANOCOVA were conducted on the engagement measures of performance. Complete ANOVA and ANOCOVA tables appear as Tables A-34 through A-45 in Appendix A. Means for these ten engagements appear in Table 17. Because of a MK60 program malfunction, miss mil scores were frequently missing and therefore not included in the analysis.

Table 15
ANOCOVA Summary
Seven Test and Training Engagements

	Variable						
	"Identified"	"On the way"	Score	Seconds	Rounds	Miss mils	Hits
F:	.705	4.65**	26.21***	20.45***	.44	2.88*	2.9*

* $p < .10$

** $p < .05$

*** $p < .01$

Table 16

MK60 Posttest Scores
Adjusted for Pretest Performance
Seven Test and Training Engagements

	Control	Low	High
"Identified"	98%	99%	99%
"On the way"[b]	97%	97%	100%
Engagement Score[a]	85.9	105.7	125.8
Seconds[a]	21.4	17.4	14.0
Rounds	2.3	2.3	2.2
Miss mils[c]	2.1	1.7	1.6
Hits[c]	93.6%	96.6%	98.2%

[a]Group effect significant at $p < .01$.
[b]Group effect significant at $p < .05$.
[c]Group effect significant at $p < .10$.

Table 17

MK60 Mean Scores for
Ten Test Only Engagements

	Pretest[a]			Posttest[a]		
Variable	Control	Low	High	Control	Low	High
"Identified"[b]	57%	82%	82%	96%	94%	98%
"On the way"[b]	72%	82%	83%	92%	95%	98%
Engagement Score[b]	26.7	28.7	28.6	28.5	38.2	41.3
Seconds	16.6	16.2	16.4	16.8	15.4	15.1
Rounds	1.4	1.4	1.4	1.8	1.7	1.8
Hits	43.7%	44.2%	46.9%	41.1%	50.3%	49.6%

[a]Pretest-Posttest gains are significant across all groups for all variables except Hits.

[b]Test by group interaction is significant.

A summary of the ANOVA appears in Table 18. Pretest-posttest differences are significant across all groups for five of the six variables. There was no significant increase in target hits. For engagement score there was a significant test by group interaction indicating differential improvement in performance. Score gains were 1.8, 9.5 and 12.7 for the control, low and high groups, respectively.

ANOCOVA results are summarized in Table 19. Posttest means adjusted for pretest performance are presented in Table 20. Significant group effects ($p < .05$ or better) appeared for announcing "on the way," engagement score, seconds and hits.

Table 18

ANOVA Summary (F Values)
Ten Test Only Engagements

	Source		
Variable	Group	Pre-test	Group X Pre-Post
"On the way"	6.41***	44.37***	6.13***
"Identified"	3.70***	35.46***	.61
Score	3.67**	17.18***	2.86*
Seconds	3.70**	5.13**	2.32
Rounds	1.42	69.87***	.79
Hits	1.95	.78	1.15

* $p < .10$

** $p < .05$

*** $p < .01$

Table 19
ANOCOVA Summary
Ten Test and Training Engagements

	Variable					
	"Identified"	"On the way"	Score	Seconds	Rounds	Hits
F:	5.36***	2.15	6.00***	5.98***	1.86	3.51**

** $p < .05$

*** $p < .01$

Table 20

MK60 Posttest Scores
Adjusted for Pretest Performance
Ten Test and Training Engagements

	Control	Low	High
"Identified"	96%	94%	98%
"On the way"[b]	83%	95%	98%
Engagement Score[a]	28.5	38.1	41.3
Seconds[a]	16.8	14.4	15.1
Rounds	1.8	1.7	1.7
Hits[b]	41.1%	50.3%	49.7%

[a]Group effect significant at $p < .01$.

[b]Group effect significant at $p < .05$.

These two sets of results illustrate the transfer of practice effects from one set of MK60 engagements to another. That is, performance on one set of engagements as indicated primarily by engagement score improved from pretest to posttest depending on the amount of practice received on a different set of engagements.

Posttest Only Engagements. Repeated measures ANOVA with training treatment as the between-group factor and the seven engagements on the single within-subjects factor was computed for each of the seven MK60 performance measures on the posttest only engagements. These engagements were novel to all subjects. Table 21 presents the means and Table 22 presents a summary of the ANOVA. Complete ANOVA tables appear in Appendix A as Tables A-46 through A-51. Parallel to previous results, training groups are significantly different ($p < .01$) for engagement score and for seconds. At $p < .01$, groups differed also on target hits and on announcing "on the way." Again, MK60 practice appears to improve MK60 performance.

Test Videodisc Scores. For each of the previous analyses there was a significant difference in engagement scores. (See summary Tables in Appendix A.) As described in Field Trial I there appears to be some discrepancy between scores obtained and engagement maximum value assignments. There is also an apparent discrepancy between the average scores of the training engagements and those of the testing only engagements. Examination of the

Table 21

MK60 Mean Scores for
Seven Posttest Only Engagements

	Posttest		
	Control	Low	High
"Identified"	90%	89%	93%
"On the way"[b]	86%	84%	91%
Engagement Score[a]	17.3	19.1	29.3
Seconds[a]	18.6	18.3	17.1
Rounds	1.4	1.3	1.5
Hits[b]	27.7%	26.7%	35.9%

[a]Groups are significantly different at $p < .01$.

[b]Groups are significantly different at $p < .10$.

individual engagement means reveals that several testing engagements were extremely difficult. For engagements 5, 10, and 12, the proportion of students achieving a hit was 2.0%, 10.0% and 11.0% on the pretest administration and 2.0%, 17.0% and 11.0% for the posttest administration. Engagements 16, 18, and 19 were posttest only engagements for which proportions of students achieving hits were 5.5%, 5.5%, and 12.2%.

Table 22
ANOVA Summary
Seven Posttest Only Engagements

	Variable					
	"Identified"	"On the way"	Score	Seconds	Rounds	Hits
F:	2.54*	.712	4.91***	5.42***	1.05	2.59*

* $p < .10$

*** $p < .01$

Composite MK60 Performance. For each student, average scores for MK60 engagement score, seconds, rounds, miss mils and hits were computed across the 17 pretest engagements and across the 24 posttest engagements. Prior to calculating means, missing data were estimated using the Yates procedure described in Field Trial I. Because of the evidence for group differences on the posttest, the Yates procedure for estimating missing data was conducted separately for the (1) pretest data matrix, (2) control group posttest data matrix, (3) low group posttest data matrix and, (4) high group posttest data matrix.

The average posttest scores were then entered as the criterion set in a MANOVA. A Wilk's Lambda of .55 with $F = 7.15$ ($df = 10, 190$) was significant at $p < .01$ indicating again a difference in training treatment groups on the posttest. ANOVA were computed on each of the five average scores. Four of the five variables exhibited group effects including score ($F = 18.81$, $p < .01$), seconds ($F=20.55$, $p < .01$), miss mils ($F=11.94$, $p < .01$) and hits ($F = 3.79$, $p < .05$). Treatment group means for these student averages are presented in Table 23.

Intercorrelations Among MK60 Scores and Training. Number of engagements practiced during training were counted for low and high MK60 trained students. Students in the low intensity group practiced an average of 100.5 engagements ($s = 13.5$); students in the high intensity group practiced an average of 167.1 engagements ($s = 9.6$).

Correlations between amount of training engagements and MK60 posttest average scores are presented in Table 24 with and without the effects of the pretest held constant. The results are similar to the MANOVA and ANOVA for these performance scores except for the non-significant relationship between MK60 practice and hits achieved. Independent of pretest performance level,

Table 23

Mean MK60 Scores
Student Averages of Seventeen
Pretest and Twenty-four Posttest Engagements

	Control (n=36)		Low (n=35)		High (n=33)	
Variable	Pre	Post	Pre	Post	Pre	Post
Score	34.6	42.1	37.9	53.7	34.4	62.3
Seconds	24.1	18.6	23.0	16.6	24.6	15.4
Rounds	2.0	1.8	2.0	1.8	1.9	1.8
Miss mils	4.2	3.9	3.9	2.8	3.6	2.6
Hits	58.6%	56.1%	60.8%	67.1%	58.2%	62.6%

Table 24

Correlation Between Amount of MK60 Practice and MK60 Posttest Performance (N=104)

	Engagement Score	Seconds	Rounds	Miss Mils	Hits
Zero-order	.51**	-.53**	.01	-.44**	.16
Partial correlation with pretest performance held constant	.54**	-.56**	.03	-.42**	.16

** $p < .01$

Approximately 30% of the variance in posttest variance for engagement score is attributable to differential amounts of training.

Ability Pretests

Two ability pretests were administered to BAT students prior to any gunnery training.

The target detection test contained twenty-one items, two of which were perfectly correlated for 104 students who had completed the field trial through MK60 training. Cronbach's alpha for the remaining twenty was .50 and was judged unacceptable. A factor analysis without rotation was conducted and the nine items loading .30 or greater on the first principal factor were selected for inclusion in the target detection test. These items obtained a somewhat more acceptable Cronbach's alpha of .69. The unrotated factor matrix is presented as Table A-52 in Appendix A. For each student a detection test score was calculated as the number correct out of these nine items.

The tracking test consisted of four trials, each measured for time to track, length of the traced line inside the track and length of the traced line outside the track. These twelve measurements were submitted to a factor analysis with varimax rotation. Three factors were extracted. The first factor included the two tracking line measurements for each of the second, third, and fourth trial with loadings all greater than .70. The second factor included the four time assessments with loadings all greater than .78. The third factor was defined by the line measurements for the first trial only. The rotated factor matrix is presented in Table A-53 in Appendix A.

Based on this evidence for the uniqueness of trial one, it was deemed a practice trial and not included in any further calculations. For each student, total time for the three remaining trials was assessed for tracking

time. Tracking error was calculated as the ratio of the sum of the lengths of the line segments traced outside the track divided by the sum of the total lengths of the traced lines.

Correlations between the three ability pretest scores and the MK60 student average scores are presented in Table 25. Detection score and tracking error are unrelated to MK60 performance. Tracking time is consistently related to MK60 scores, particularly for the MK60 pretest.

Table 25

Correlations Between Ability Pretests and MK60 Performance

	Pretest				
	Score	Seconds	Rounds	Miss Mils	Hits
Detection (n=101)	.06	-.08	.05	-.02	.08
Tracking Time (n=102)	-.37**	.38**	-.21**	.21**	-.32**
Tracking Error (n=102)	-.02	.04	.04	.10	-.08

	Posttest				
	Score	Seconds	Rounds	Miss Mils	Hits
Detection (n=100)	.06	-.01	.16	.12	.01
Tracking Time (n=102)	-.23**	.18*	-.12	.14	-.25**
Tracking Error (n=102)	.11	-.10	.00	.01	.13

* $p < .05$

** $p < .01$

Transfer of Training - Dry Fire Analysis

As with Field Trial I, extensive missing data precluded analysis of individual dry fire engagements. A discussion of the reasons for the missing data is presented in Appendix B of Volume I. Only one student had complete data for all engagements. In addition, no two BAT companies received an identical dry fire exercise. Therefore, the dry fire analysis was conducted on mean dry fire scores calculated for each student as described below.

First the Yates procedure was used as described for the Field Trial I dry fire with one modification: missing data estimates were based on each company's data matrix. The Yates procedure was conducted separately on each company because of potential mean differences in dry fire performances stemming from the variations in the dry fire exercise. After missing data points were estimated by the Yates procedure, mean scores were calculated for each student for the same set of dry fire variables assessed and described in Field Trial I. A total of 83 students had at least three first round engagements from which to base missing data and subsequent mean performance calculations. The control group had 28, the low group had 29, and the high group had 26. One company had only one subsequent fire command engagement. Nine students were not scored on that engagement leading to a total sample of 74 for the second round dry fire measures with 25, 25 and 24 students in the control, low and high groups, respectively.

To check the assumption of between company mean differences in performance, a MANOVA was conducted with company as the independent variable. The MANOVA examined the time measures, elevation errors, and lead errors based on standard leads. A Wilk's Lambda of .27 (F = 4.71, df = 21. 175) was significant at p <.01. ANOVA calculated on these criterion scores obtained significant F for each of the time measures, for both first and second round lead errors, and for second round elevation error. These ANOVA are presented in Table 26. Mean dry fire performance scores for each company are presented in Table 27.

Because the implementation of the training design was identical for each company, these mean differences between companies are assumed to be irrelevant for the MK60 field trial. While there may be other unknown differences as well, certainly the differences in the difficulty of the four versions of the BAT dry fire exercises could explain the company differences. In order to remove these company effects, the remaining dry fire analyses were conducted on scores standardized within each company.

Two MANOVA were conducted on subsets of these standardized dry fire scores with training treatment as the independent variable. The first MANOVA examined the time measures, elevation errors, and standard lead errors as the criterion set. Wilk's Lambda of .82 (F = .89, df = 14, 124) was not significant. The second MANOVA examined the time measures, elevation errors and optimum lead errors. The Wilk's Lambda for this analysis was also not significant (.81, F = .96, df = 14, 124). Separate ANOVA were calculated on each of these criterion measures. Results are presented in Table 28. None are significant. Table 29 presents means of the unstandardized dry fire scores for the three training groups. No effects or trends are present.

Table 26

ANOVA for Company Effects
on Dry Fire Performance Scores

Variable	Group MS	Error MS	F
Time to Acquire	32.54	8.44	3.85*
Time to Lay	33.10	3.65	9.06**
First Round:			
Lead	11.24	.78	14.35**
Elevation	.06	.07	.82
Time to Adjust	11.93	2.01	5.95*
Second Round:			
Lead	9.87	2.49	3.97*
Elevation	.50	.15	3.38*

* $p < .05$

** $p < .01$

Table 27

Dry Fire Scores by Company

Variable		Company A (n=21)[c]	B (n=20)	C (n=24)	D (n=18)
Time to Acquire[a]		5.65	8.00	5.24	6.96
Time to Lay[a]		6.79	4.67	6.44	7.88
1st Round Lead Error[b]	Standard	1.96	3.78	2.35	3.03
	Optimum	2.94	4.30	2.98	3.52
1st Round Elevation Error		.30	.40	.28	.29
Time to Adjust[a]		4.06	2.67	4.17	4.41
2nd Round Lead Error[b]	Standard	6.58	3.96	4.75	4.25
	Optimum	6.28	3.12	4.52	4.05
2nd Round Elevation Error[b]		1.45	1.04	1.06	.88

[a]Seconds

[b]Mils

[c]Only one subsequent fire command engagement was scorable for Company A and it was not scorable for all subjects. N for second round Company A data is 12 for tracking errors and 14 for time to adjust.

Table 28

ANOVA for Training Effects
on Dry Fire Performance
(N = 71)

Variable	Group MS	Error MS	F
Time to Acquire	.05	.98	.04
Time to Lay	1.36	.89	1.53
First Round:			
Standard Lead Error	.74	.97	.77
Optimum Lead Error	1.01	.95	1.08
Elevation Error	.19	.91	.21
Time to Adjust	1.95	.92	2.11
Second Round:			
Standard Lead Error	.07	.98	.07
Optimum Lead Error	.10	.97	.11
Elevation Error	.47	1.02	.46

Table 29

BAT Field Trial Dry Fire Means
(Unweighted means for four BAT companies)

Variable		Control	Low	High
Time to Acquire		6.57	6.77	6.10
Time to Lay		6.75	6.06	6.57
1st Round Lead Error	Standard	2.66	2.87	2.87
	Optimum	3.28	3.50	3.62
1st Round Elevation Error		.32	.29	.34
1st Round Radial Error	Standard	2.75	2.99	3.19
	Optimum	3.40	3.61	3.75
Time to Adjust		3.51	3.58	4.36
2nd Round Lead Error	Standard	4.93	5.06	4.67
	Optimum	4.59	4.70	4.34
2nd Round Elevation Error		1.17	1.03	1.07
2nd Round Radial Error	Standard	5.05	5.34	5.04
	Optimum	4.72	4.98	4.72

Transfer of Training - BAT Table VI Main Gun Performance

Live fire performance was examined by calculating percentages of rounds scored as hits, misses or lost. Differences in percentages of lost data are the results of collaboration or the lack of it with company personnel. For B and C, sensing was conducted by the research staff who at times had trouble identifying which target was being engaged.

These companies also most clearly represent the situation deemed most accurate by Eaton and Whalen (1980). That is, the close collaboration with company personnel provide the best information about specifically what target was being engaged for each round, and targets were reserved for tanks with study participants firing. Researchers and company personnel were sensing from a tower with binoculars.

An ANOVA was conducted on percent of hits for the three training groups, shown in Table 30. The obtained F of 1.24 was not significant.

Table 30

BAT Table VI A
Live Fire Sensing Data

Company	n	Hits	Percentage of Misses	Lost
"A"				
Control	10	66.2	32.3	1.5
Low	8	87.7	12.2	0.0
High	7	72.3	21.3	6.4
"B"				
Control	9	52.1	41.7	6.2
Low	8	47.6	50.0	2.4
High	8	51.1	46.7	2.2
"C"				
Control	7	31.7	60.9	7.3
Low	10	14.0	77.2	8.8
High	8	53.3	24.4	22.2
"D"				
Control	9	77.8	22.2	0.0
Low	9	54.0	46.0	0.0
High	9	57.1	42.9	0.0
All Control	35	58.6	37.8	3.5
All Low	35	48.8	48.1	3.1
All High	32	58.0	34.5	7.5
TOTAL:	102	55.0	40.3	4.6

Simulated Test Validity

Correlations were calculated between 14 predictor measures (the 10 pretest/posttest MK60 average scores, the three ability test scores, the number of MK60 practice engagements) and the 13 dry fire scores. Out of 182 correlations, only eleven (6.0%) were statistically significant. Six of those were in the direction opposite to that expected. These correlations are presented in Table A-54 in Appendix A. There appears to be little relationships across the MK60, ability test and dry fire domains. Again, MK60 scores appear to have little validity for predicting dry fire performance.

The correlation between MK60 pretest score and percent of hits during live fire was also calculated. That correlation was -.12 (n.s.), indicating that the MK60 is not predictive of M60A1 live fire performance.

MK60 Test Stability. Similar to the Field Trial I analysis, the test-retest reliability of the relative order of students' MK60 performance scores between the pretest and posttest was examined by the partial correlation across the 104 BAT students between pretest and posttest average scores with training held constant. These partial correlations, along with the analogous zero-order correlations, appear in Table 31. While larger than those for the AOB students, the correlations are not particularly large. With training differences held constant, approximately 18% of the variance in posttest engagement scores is attributable to pretest performance level.

Table 31

Correlation Between MK60 Pretest-Posttest Performance Scores

	Engagement Score	Seconds	Rounds	Miss Mils	Hits
Zero-order	.38**	.35**	.21*	.37**	.17*
Partial correlation with pretest performance held constant	.43**	.42**	.21*	.34**	.17

* p .05

** p .01

Instructors' Opinions of MK60 Training

Because of scheduling difficulties, assistant instructors were involved with little consistency in the AOB field trial. Therefore, no questionnaire data were gathered from AOB instructors. On the other hand, five BAT instructors were consistently available, with four of those instructors being present for a minimum of eight training sessions. The fifth instructor was transferred prior to the completion of the study. These four completed the evaluation questionnaire. This questionnaire contained four sections dealing with attitudes and experiences of the instructors in the use of the training device. A fifth section asked about each instructor's "history" as an instructor. Instructors were invited to provide written comments frequently throughout the questionnaire. The results of this evaluation are discussed by questionnaire section below.

Section A. The nine items in Section A concerned frequency of problems experienced with several operating features of the device. Instructors were asked to rate each item on a seven point scale ranging from 1 (always had problems) to 7 (never had problems). The means and standard deviations for each item are shown in Table 32.

As can be seen, the means all fall on the extremely favorable end of the scale, i.e., toward "never had any problems," with five items receiving this rating unanimously. No item received an average of less than 5.75 which is well above the value of 5 or "seldom."

Table 32

Mean Rating of BAT Instructors
on Frequency of Problems
(N=4 unless noted otherwise)

Item	Mean	Std. Dev.
1. Inserting videodisc record[a]	7.00	0
2. Inserting floppy disc	7.00	0
3. Demonstrating to student	6.50	1.00
4. Starting the engagements	7.00	0
5. Observing scoring information	7.00	0
6. Viewing scene in monitor	5.75	1.50
7. Viewing scene in device	5.75	1.50
8. Seeing round simulations	6.75	.50
9. Hearing sound output	7.00	0

[a] N = 3

Section B. In Section B, seven items were presented about the realism of various features of the MK60. The instructors were asked to rate how much the MK60 provided a feeling of live fire at real targets on a five-point scale ranging from 1 (not at all realistic) to 5 (extremely realistic). The means and standard deviations for each item are shown in Table 33.

Again, the means are highly favorable, i.e., they all tend toward a rating of 5 or "extremely realistic."

Table 33

Mean Rating of BAT Instructors
on Realism of Certain Features
(N=4)

Item		Mean	Std. Dev.
10.	Switches and indicator lights	4.50	.57
11.	Cadillac controls	4.50	.57
12.	Sight picture before firing	4.50	.57
13.	Sight pictures after firing	4.75	.50
14.	Sound effects of tank turret	4.25	.96
15.	Sound effects of firing	4.50	.57
16.	Sound of fire commands	4.75	.50

Section C. There were four items in Section C concerned with information provided on the MK60 display following each engagement. Instructors were asked to rate the helpfulness of each type of information in coaching their trainees. A five-point scale ranging from 1 (not at all helpful) to 5 (extremely helpful) was provided. Means and standard deviations for each item are provided in Table 34.

Table 34

Mean Rating of BAT Instructors on Helpfulness
of Display Information
(N=4)

Item		Mean	Std. Dev.
17.	Engagement score	4.75	.50
18.	Engagement time	4.25	.96
19.	Number of rounds used	4.75	.50
20.	Miss distance in mils	4.75	.50

Section D. This section of the questionnaire provided ten general statements about the MK60. While each item included a five-point rating scale, the descriptors for points on the scale varied among the items. These items are discussed individually or in subsets as the scale descriptors and general content of the items permits.

Item 21, "Using the MK60 as a trainer was:" was rated on a scale from 1 (very difficult) to 5 (very easy). The mean rating was 4.75 with a standard deviation of .50. All of the instructors found the MK60 easy to use as a trainer.

In two items, the instructors were asked to rate the efficiency of training with the MK60, compared to another device. The scale provided ranged from 1 (much less efficient) to 5 (much more efficient). The summary results for the two devices were:

		Mean	Std. Dev.
Item 22.	M55 Laser	4.50	.58
Item 23.	.22 cal. Brewster	3.50	1.29

It appears that the instructors found the MK60 quite a bit more efficient for training than the M55 laser, but fairly similar in efficiency when compared to the .22 cal. Brewster.

In Item 24, the instructors were asked to rate the difficulty of the practice engagements given with the MK60 using a scale from 1 (much too difficult) to 5 (much too easy). The response "About right" was chosen unanimously. (Mean = 3.00, s = .00) This item is concerned with the scenarios selected for practice engagements rather than the operating characteristics of the MK60 device.

Item 25, "If combat units had MK60 devices to practice on, I think their gunnery skills would:" was rated on a scale from 1 (get much worse) to 5 (get much better). A mean of 4.50 and standard deviation of .58 were obtained for this item, indicating that the instructors, as a group felt gunnery skills would be more than "somewhat better" but less than "much better."

On two items, the instructors were asked to compare the teaching of M60A1 skills using the MK60 device to learning these skills using the regular or conventional BAT training tables. The scale provided ranged from 1 (much less thoroughly) to 5 (much more thoroughly). The results were:

		Mean	Std. Dev.
Item 26.	Compared to Tables I, II, and III	3.50	.58
Item 27.	Compared to Table IV	3.25	.50

In general, the instructor group indicated that the thoroughness of training using the MK60 device was about the same as using the Tables. It should be noted that provision of training on the MK60, as part of the field trial procedure, was a substitution or augmentation for training on these Tables in

time only. The gunnery skills addressed in the Tables were not specifically "copied" during the MK60 practice.

The remaining three items of Section D were stated in the form of recommendation with a scale of 1 (strongly disagree) to 5 (strongly agree). These are summarized below:

		Mean	Std. Dev.
Item 28.	Training with the M55 laser should be replaced by training on the MK60:	4.25	.96
Item 29.	Training with the .22 cal. Brewster device should be replaced by the MK60:	3.25	1.26
Item 30.	Training with the MK60 should be used in addition to the normal training:	5.00	.00

As a group, the instructors "somewhat agree" with replacing training on the M55 laser by training on the MK60. However, they are clearly equivocal (and more disparate in their opinions) about replacing training with the .22 cal. Brewster by training on the MK60. They were unanimous in their opinion that the MK60 should be used in conjunction with normal training.

Section E. Each instructor was asked how long he had taught tank gunnery. The teaching experience of this group ranged from one year to ten years, four months. The group mean was 45 months with a standard deviation of 53 months.

Each instructor was also asked which of the MK60 training sessions he had taught. All four of the instructors responded that they had taught both of the MK60 training modules for BAT students.

Written-in Comments. The written comments added by the BAT instructors were examined. It was found that no single comment was made by more than one instructor. All comments have been reproduced in Appendix C of Volume I.

Device Reliability

Records were maintained of the use of each device during the field trials. Users recorded their times of use as well as device failures.

Excluding one device, which was not used regularly because its scoreboard display did not function properly, the mean period of use during the field trials was approximately 120 hours. Minor problems were observed in each device. These consisted of items such as reticle failure, premature display of an engagement, occasional bypass of a programmed engagement,

display of an inappropriate target scene, and incorrect estimate of miss distance. The latter was related to the point in an engagement when a round was fired. If the round was fired a fraction of a second or more before the engagement ended, the poisiton of the round at that time--on way to target--was reported by the device computer.

The other device problems cited above tended to be self-correcting. For example, when a premature target scene was displayed, pressing the "start" button for the next engagement generally removed the unwanted scene and presented the correct one.

As mentioned earlier, one device had a faulty scoreboard display. While this problem also tended to be self-correcting at times, it could not be relied upon. Perceptronics personnel attempted several times to correct the problem, but they were not successful.

A problem late in the field trials consisted of a broken ammo control handle. Two devices experienced this. Local maintenance personnel were able to correct the problem, but the device remained essentially useless pending repair. The trigger switch of one device remained in the "on" position, and it required correction by maintenance personnel. Poor color quality of the target scene display in all devices was common and although repeated attempts were made to correct this problem, it tended to remain. Sometimes the displays were black and white, and at other times red and white or green and white.

GENERAL DISCUSSION AND CONCLUSIONS

Training Opinions

Students' and instructors' opinions reflect the excitement and enthusiasm the MK60 tank gunnery trainer has generated. The device is viewed as realistic even though it is a relatively compact table-top simulator. It is challenging for the students. Even the BAT high intensity students who averaged 167 repetitions on just twenty different engagements did not appear to be satiated. Students monitored their scores and were motivated to improve. It is viewed as an efficient training device by instructors. Certainly there was very little hesitancy to utilize the device for this experimental field trial.

Training Effectiveness

The analysis of the MK60 pretests and posttests clearly supports the conclusion that MK60 performance improves with practice. The improvement appears due primarily to the speed of achieving target hits. The more students practice, the faster they achieve a hit on the target, and consequently, the higher their engagement scores. There tends to be little improvement in number of rounds used, or average miss mils, however. During MK60 training no particular emphasis was given to conserving ammunition, and the engagement score calculated by the MK60 was more sensitive to time than to rounds used. Thus, students learned to emphasize speed, perhaps at the cost of improvements in tracking precision.

The consistent pretest-posttest differences also suggest that the AOB and BAT control groups improved on the device. It is tempting to suggest that the improvement of AOB control students was due to transfer of practice on the turret trainer mounted M55 Laser, or for BAT students the M55 Laser and .22 cal. Brewster device. That conclusion must remain speculative because the pretest can be viewed as previous practice prior to the posttest. In order to separate the effects of previous practice from other training, the posttest-only items were not included in the pretest. However, because of the incomparability of engagement scores across engagements, the scores of the posttest-only engagements could not be used to judge the practice effects.

An alternative design to isolate MK60 practice effects for the control group would have been to administer a posttest immediately after the pretest. To some extent that condition is represented by the BAT module 1 training period. The student went immediately from the pretest to training. Records kept during this training showed that for the seven engagements included on the pretest, the average score for their first repetition during training was 88.46. This compares to a 85.96 average for the control group posttest. Thus, the control group does not appear to have improved more than expected based on the experience of taking the pretest. Its practice on the M55 Laser and .22 cal. Brewster devices does not appear to transfer to the MK60. While this does not mean that MK60 skill will not transfer to the M60A1 tank, it does question the validity of the MK60 as a measuring tool for assessing M60A1 skills. Of course, this is predicated on the assumption that BAT

students' M60A1 moving target skills did improve as a result of M55 Laser and .22 cal Brewster training while, in fact, students received much more practice on stationary than moving targets with these two devices.

In addition to the improvements in engagement scores which indicate improved control manipulation, there is also evidence from both AOB and BAT evaluations that the MK60 can be used to reinforce procedural aspects of gunnery. In both studies, there was consistent evidence of MK60 trained students more frequently remembering to announce "On the way." In the AOB study MK60 students also remembered to announce "Identified" more frequently. It was observed during training that, particularly during the early stages, instructors would frequently reinforce these procedural steps. As training continued, students would also remind each other. As a result, these responses became habitual.

Transfer of Training

To assess transfer of MK60 acquired skills, two M60A1 exercises were monitored: a dry fire exercise with moving targets to assess the apparent strength of the MK60, and Table VI main gun performance, consisting primarily of stationary targets. In either case, there was no consistent trend showing the MK60 to be superior in training transfer to the currently administered programs of instruction for AOB and BAT classes. These generally "no difference" results are always difficult to interpret with certainty.

Nine dry fire variables (three time variables and six accuracy variables) were examined for group differences for BAT and for AOB students. In neither study was there a significant training effect on a composite of all variables. Out of the eighteen individual tests (nine for each study), one test was significant at the traditionally accepted five percent error rate for which one out of twenty such tests would be expected to be statistically significant by chance alone. That was for first round average optimum lead error. That result is problematic because the low intensity group responded the most accurately. A priori, there was no reason to expect a curvilinear relationship between amount of MK60 practice and firing accuracy; therefore, post hoc explanations are risky. Certainly these results cannot be interpreted to mean that MK60 practice, in general, leads to increased lead accuracy.

One other of the AOB dry fire variables approached traditional significance. With a ten percent level of confidence, it could be argued that the MK60 promotes faster performance as signified by the time to adjust measure. Certainly practice on the MK60, because of the low first round hit probabilities experienced by the students, may promote a readiness to fire a second round. In addition, MK60 posttest performance showed consistent speed differences for both AOB and BAT students. It seems reasonable to suggest that the MK60 does reinforce speed of responding.

On the other hand, the remaining accuracy scores provided little evidence of differential training. However, the reliability examination conducted as part of Study I suggests that students' performance from one engagement to the next is difficult to predict. Thus, the likelihood of being able to predict performance from training is considerably reduced. In

addition, in the case of elevation errors, the average errors were relatively small for generally all students. Consequently, the room for improvement and the margin for observing differential training effects is small.

Within the constraints of the range facilities, the dry fire targets were selected to reflect realistic parameters of target speed and ammunition, and to a more limited extent, range. The variety of target speeds utilized was greater than for normal training and, as a result of the particular training engagements provided with the MK60, greater also than for MK60 training. Thus, neither regularly trained nor MK60 trained students were experienced with the higher speed targets that made up approximately onethird of the dry fire engagements. No differences in performance should have been expected for these targets.

Parenthetically, it may be noted that the average lead errors are four or more times as large as the average elevation errors (see Tables 9 and 28). Standard practice is to announce only the elevation error in a sensing or observation (i.e., over, short or "doubtful", which means correct elevation). Thus, the announcement is for the dimensions with the least likelihood for error, at least for targets moving at a variety of speeds as in the dry fire test.

On the more positive side, for the BAT students in Study II a considerable portion of the conduct of fire program of instruction training was removed from the schedule of the MK60 trained students. They spent eight hours with MK60 training instead of M55 Laser based training. Viewed from this perspective, the "no difference" results for both the dry fire and live fire assessments mean the MK60 is certainly not detrimental to student learning. A reasonable argument could be made that, at least at the early stage of development, the MK60 could be used instead of the turret trainer mounted M55 Laser. AOB students and BAT instructors, however, seemed to agree in their questionnaire responses that some turret training is a necessary step prior to advancing to main gun rounds fired from the M60A1. The design of the present study could not empirically test their opinions since all students received turret trainer training prior to the dry fire and live fire test. Their opinions do suggest caution in the substitution of the MK60 for advanced practice on the turret trainer.

Based on these results, on informal observations of the MK60 training periods, and on the analyses of M60A1 skill requirements (Melching, Campbell, & Hoffman, 1982), a number of suggestions for modifications and improvements in the design of the MK60 have been offered in Appendix D of this Volume.

Simulated Test Validity

Correlations between pretest and posttest MK60 scores for AOB and BAT students, even when adjusted for differences in intervening MK60 training, are moderate at best. This suggests that the test-retest reliability of the MK60 may be weak. The predictive validity of MK60 scores for dry fire and live fire performance is poor. Unfortunately, these results are not any more encouraging then previous attempts to predict M1 gunnery performance (Campbell & Black, 1982).

Comments

The MK60 appears to have a very positive acceptance by students and instructors as a device for teaching M60A1 gunner skills. It appears that the repeated practice reinforces procedural responses and emphasizes speed of responding. Both of these attributes are tremendously important when viewed against estimates which argue that threat forces are likely to highly outnumber U.S. and Allied forces. The repeated practice which can be received by the student, largely without the aid of an instructor and with no loss of enthusiasm and motivation, is great enough to lead to habituation of responses.

Because of the difficulty of measuring tracking and lay accuracy for students performing on the M60A1 tank, less can be definitely said about the MK60's potential for teaching manipulation and tracking skills. From Study II, certainly the substitution of MK60 practice for turret trainer practice was not shown to be detrimental. This is a rather positive finding since the turret trainer provides manipulation response characteristics identical to the M60A1 tanks. For institutional training, where students are just learning which direction to move the handle control to achieve the desired response of reticle in relation to target, there is less concern about the exactness of control operating characteristics than might be the case if the MK60 were being evaluated to fine-tune the responses of the experienced gunner.

Overall, this assessment of the MK60 as a prototype training suggests that the potential of the MK60 concept bears further exploration. For example, the potential for variety in moving target simulators, which is already greater than presently available in the current training program, seems limited only by the imagination of film makers for the MK60 videodiscs. The suggestions in Appendix D of Volume I present a number of alterations that could expand the use of the MK60 to M60A1 training objectives for which its capability is now limited.

SUMMARY

The purpose of this field trial was to assess (1) the training effectiveness of the MK60 for teaching gunnery skills, (2) the transfer of that training to M60A1 tank performance, (3) the validity of the MK60 for predicting M60A1 performance, and (4) the opinions of students and instructors.

Performance on the MK60 device increased as a direct function of practice time and practice engagements. That is, for both AOB and BAT students, scores obtained on the MK60 were significantly better after training than before training. Furthermore, those students with a higher amount of MK60 training improved more than those with a lower amount. The improvement appeared to be due primarily to increased speed in achieving target hits, and in consistency of issuing verbal responses to fire commands. There tended to be little improvement in number of rounds used or average miss distance. The improvements may be due at least partially to the students' high motivation during training and the relatively concentrated practice which was available. Thus, it appears that the MK60 is effective in teaching certain tank gunnery skills.

Transfer of training from the MK60 device, measured by dry fire and live fire performance on the M60A1 tank, appeared equal to that produced by alternative devices in current gunnery programs. That is, there were no detectable differences in M60A1 performance between students who had received MK60 training and those who had not. Given the limited MK60 training materials (i.e., videodisc and associated programming) available during the field trials, improvements in the quality and content coverage of that material might increase the MK60's transfer of training. In addition, incorporation of suggestions made for improvements in the device might improve its transfer of training. For example, if the instructor were provided a monitor which indicated the student gunner's sight picture, he might be able to give better and more immediate feedback about the student's tracking technique.

Correlations were calculated between MK60 test scores and M60A1 dry and live fire performance in order to establish the predictive validity of the MK60. Correlations were consistently non-significant.

Opinions of both students and instructors about the MK60 were assessed by questionnaire. In general, both students and instructors were very positive toward the instruction provided by the MK60. For example, students thought the MK60 was challenging, and they liked practicing on the device. Instructors thought the MK60 provided realistic practice, and they strongly favored the addition of the MK60 to current training.

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Appendix A

Volume I

Data Analysis Tables

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Table A-1

Mean Questionnaire Responses From
AOB Students

Items	Low Group (N=25)	High Group (N=22)
Section A. Strongly Disagree (1) to Strongly Agree (5).		
1. I liked practicing on the MK60 training device.	4.44	4.23
2. When I was practicing on the MK60 trainer, I could imagine that I was firing an M60A1 tank.	3.72	3.59
3. If I could see the target, I could hit it.	4.04	3.96
4. Most of the practice engagements were too hard.[a]	3.40	3.96
5. I had trouble finding the targets.[a]	2.60	2.18
6. Practice sessions on the MK60 were too long.[a]	4.28	3.82
7. It bothered me that the ammo handle was in the wrong place on the MK60.[a]	3.44	3.64
8. When practicing on the MK60, I often forgot to say "IDENTIFIED" or "ON THE WAY."[a]	3.08	3.86
9. I really learned how to control the reticle.	3.52	3.77
10. I though the problems on the MK60 were challenging.	4.16	4.23
11. The MK60 helped me learn how to lead moving targets.	3.72	3.64
12. I tried to better my score on the MK60 each time I practiced an engagement.	4.56	4.18
13. It was hard for me to imagine that I was really learning tank gunnery.[a]	3.88	3.59
14. I would like to continue practicing on the trainer when I am assigned to a unit.	4.24	4.00
15. I had too much practice on the MK60 trainer.[a]	4.32	4.04
16. I could train on the MK60 without an assistant instructor.	3.76	3.82
17. The amount of training time I received on the MK60 was not enough to learn M60A1 gunnery.	3.56	3.73
18. I would like to have had more practice time on the MK60 trainer.	3.96	3.77
19. The assistant instructor provided useful coaching on the MK60.	2.76	2.86
20. I learned a lot on the new trainer.	3.84	3.32

[a]Scale is reversed; high numbers represent positive attitude.

Table A-1 (Cont'd)

Items	Low Group (N=25)	High Group (N=22)
Section B. Not At All Realistic (1) to Extremely Realistic (5).		
21. Switches and indicator lights.	3.68	3.77
22. Cadillac controls.	3.96	3.73
23. Sight picture before firing.	3.20	2.96
24. Sight picture after firing.	3.32	2.50
25. Sound effects of tank turret.	2.76	2.32
26. Sound effects of firing.	2.96	2.43
27. Sound of fire commands.	2.96	3.04
Section C. Not At All Helpful (1) to Extremely Helpful (5)		
28. Engagement score.	3.64	2.96
29. Engagement time.	4.24	4.09
30. Number of rounds used.	3.68	3.68
31. Miss distance in mils.	3.40	4.00
Section D. Proportion of Training Time Allotted		
32. Willey	11%	11%
33. MK60	40%	31%
34. Turret trainer	49%	60%

Table A-2

ANOVA Summary Table For
"Identified" on MK60 Engagements
Used For Pretest and Posttest
for AOB Students

Source	df	MS	F
Between Subjects			
Group	2	3.479	4.331**
Subjects/Group	65	.803	
Within Subjects			
Pre-Post	1	65.955	109.595***
Group x Pre-Post	2	1.044	1.735
Pre-Post x Subjects/Group	65	.602	
Items	6	.041	.536
Group x Items	12	.107	1.412
Items x Subjects/Group	390	.076	
Pre-Post x Items	6	.051	.677
Group x Pre-Post x Items	12	.114	1.513
Pre-Post x Items x Subjects/Group	390	.076	

*$p < .10$

**$p < .05$

***$p < .01$

Table A-3

ANOVA Summary Table For
"On The Way" on MK60 Engagements
Used For Pretest, Posttest, and Training
for AOB Students

Source	df	MS	F
Between Subjects			
Group	2	2.274	2.914*
Subjects/Group	63	.780	
Within Subjects			
Pre-Post	1	67.255	122.296***
Group x Pre-Post	2	.428	.779
Pre-Post x Subjects/Group	63	.550	
Items	6	.117	1.633
Group x Items	12	.080	1.121
Items x Subjects/Group	378	.072	
Pre-Post x Items	6	.056	.741
Group x Pre-Post x Items	12	.078	1.037
Pre-Post x Items x Subjects/Group	378	.076	

*$p < .10$

**$p < .05$

***$p < .01$

Table A-4

ANOVA Summary Table For
Score on MK60 Engagements
Used For Pretest and Posttest
for AOB Students

Source	df	MS	F
Between Subjects			
Group	2	18683.592	2.700*
Subjects/Group	64	6920.440	
Within Subjects			
Pre-Post	1	239551.310	62.709***
Group x Pre-Post	2	4654.411	1.218
Pre-Post x Subjects/Group	64	3820.022	
Items	6	790847.910	205.062***
Group x Items	12	2803.763	.727
Items x Subjects/Group	384	3856.623	
Pre-Post x Items	6	5832.036	1.894*
Group x Pre-Post x Items	12	4380.032	1.422
Pre-Post x Items x Subjects/Group	384	3079.736	

*$p < .10$

**$p < .05$

***$p < .01$

Table A-5

ANOVA Summary Table For
Seconds on MK60 Engagements
Used For Pretest and Posttest
for AOB Students

Source	df	MS	F
Between Subjects			
Group	2	1521.385	3.018*
Subjects/Group	64	504.107	
Within Subjects			
Pre-Post	1	16469.682	69.068***
Group x Pre-Post	2	32.744	.137
Pre-Post x Subjects/Group	64	238.454	
Items	6	3303.720	17.638***
Group x Items	12	144.044	.769
Items x Subjects/Group	384	187.311	
Pre-Post x Items	6	140.562	.818
Group x Pre-Post x Items	12	89.614	.522
Pre-Post x Items x Subjects/Group	384	171.742	

*$p < .10$

**$p < .05$

***$p < .01$

Table A-6

ANOVA Summary Table For
Number of Rounds on MK60 Engagements
Used For Pretest and Posttest
for AOB Students

Source	df	MS	F
Between Subjects			
Group	2	.424	.170
Subjects/Group	65	2.491	
Within Subjects			
Pre-Post	1	43.733	17.506***
Group x Pre-Post	2	1.272	.509
Pre-Post x Subjects/Group	65	2.498	
Items	6	45.455	19.198***
Group x Items	12	2.128	.899
Items x Subjects/Group	390	2.368	
Pre-Post x Items	6	5.367	2.591**
Group x Pre-Post x Items	12	1.100	.531
Pre-Post x Items x Subjects/Group	390	2.072	

*$p < .10$

**$p < .05$

***$p < .01$

Table A-7

ANOVA Summary Table For
Miss in Mils on MK60 Engagements
Used For Pretest and Posttest
for AOB Students

Source	df	MS	F
Between Subjects			
Group	2	31.977	2.472*
Subjects/Group	59	12.934	
Within Subjects			
Pre-Post	1	237.791	25.888***
Group x Pre-Post	2	9.439	1.028
Pre-Post x Subjects/Group	59	9.185	
Items	6	76.972	7.048**
Group x Items	12	16.342	1.496
Items x Subjects/Group	354	10.922	
Pre-Post x Items	6	12.688	1.159
Group x Pre-Post x Items	12	9.645	.881
Pre-Post x Items x Subjects/Group	354	10.946	

*$p < .10$

**$p < .05$

***$p < .01$

Table A-8

ANOVA Summary Table For
Number of Hits on MK60 Engagements
Used For Pretest and Posttest
for AOB Students

Source	df	MS	F
Between Subjects			
Group	2	.105	.576
Subjects/Group	65	.182	
Within Subjects			
Pre-Post	1	2.969	22.447***
Group x Pre-Post	2	.048	.363
Pre-Post x Subjects/Group	65	.132	
Items	6	33.942	294.297***
Group x Items	12	.051	.439
Items x Subjects/Group	390	.115	
Pre-Post x Items	6	.120	1.027
Group x Pre-Post x Items	12	.039	.331
Pre-Post x Items x Subjects/Group	390	.117	

*$p < .10$

**$p < .05$

***$p < .01$

Table A-9

ANCOVA Summary Table For
"Identified" on MK60 Engagements
Used For Pretest and Posttest
for AOB Students

Source (Adjusted)	df	MS	F
Between Subjects			
Group	2	3.888	10.129***
Subjects/Group	64	.384	
Within Subjects			
Items	6	.052	.950
Group x Items	12	.094	1.730*
Items x Subjects/Group	389	.054	

*p < .10

**p < .05

***p < .01

Table A-10

ANCOVA Summary Table For
"On The Way" on MK60 Engagements
Used For Pretest, Posttest and Training
for AOB Students

Source (Adjusted)	df	MS	F
Between Subjects			
Group	2	1.491	6.062***
Subjects/Group	62	.246	
Within Subjects			
Items	6	.091	1.667
Group x Items	12	.062	1.137
Items x Subjects/Group	377	.055	

*$p < .10$

**$p < .05$

***$p < .01$

Table A-11

ANCOVA Summary Table For
Score on MK60 Engagements
Used For Pretest and Posttest
for AOB Students

Source (Adjusted)	df	MS	F
Between Subjects			
Group	2	14671.814	3.179**
Subjects/Group	63	4615.481	
Within Subjects			
Items	6	139752.600	37.884***
Group x Items	12	5187.025	1.406
Items x Subjects/Group	383	3688.982	

*$p < .10$

**$p < .05$

***$p < .01$

Table A-12

ANCOVA Summary Table For
Seconds on MK60 Engagements
Used For Pretest and Posttest
for AOB Students

Source (Adjusted)	df	MS	F
Between Subjects			
Group	2	552.958	2.826*
Subjects/Group	63	195.674	
Within Subjects			
Items	6	1571.957	10.432***
Group x Items	12	80.271	.533
Items x Subjects/Group	383	150.680	

*$p < .10$

**$p < .05$

***$p < .01$

Table A-13

ANCOVA Summary Table For
Number of Rounds on MK60 Engagements
Used For Pretest and Posttest
for AOB Students

Source (Adjusted)	df	MS	F
Between Subjects			
Group	2	1.576	.802
Subjects/Group	64	1.966	
Within Subjects			
Items	6	15.433	8.136***
Group x Items	12	.886	.467
Items x Subjects/Group	389	1.897	

*$p < .10$

**$p < .05$

***$p < .01$

Table A-14

ANCOVA Summary Table For
Miss in Mils on MK60 Engagements
Used For Pretest and Posttest
for AOB Students

Source (Adjusted)	df	MS	F
Between Subjects			
Group	2	1.185	.193
Subjects/Group	58	13.151	
Within Subjects			
Items	6	41.884	5.848***
Group x Items	12	10.930	1.526
Items x Subjects/Group	353	7.162	

*p < .10

**p < .05

***p < .01

Table A-15

ANCOVA Summary Table For
Hits on M60 Engagements
Used For Pretest and Posttest
for AOB Students

Source (Adjusted)	df	MS	F
Between Subjects			
Group	2	.091	1.177
Subjects/Group	64	.077	
Within Subjects			
Items	6	6.528	92.097
Group x Items	12	.038	.531
Items x Subjects/Group	389	.071	

*$p < .10$

**$p < .05$

***$p < .01$

Table A-16

A09 MODULE [illegible] REPETITIONS

MISSION		FIRST SCORE	FIRST SEC.	FIRST RDS.	FIRST MISS	SECOND SCORE	SECOND SEC.	SECOND RDS.	SECOND MISS	THIRD SCORE	THIRD SEC.	THIRD RDS.	THIRD MISS
1	MEAN:	56.9	12.1	1.6	2.1	86.4	7.2	1.2	0.6	81.0	6.8	1.2	0.3
(100)[a]	S.D.:	32.0	7.6	0.8	3.0	23.4	5.6	0.6	1.7	26.5	4.0	0.4	0.8
	N:		47				40				6		
2	MEAN:	52.2	12.6	1.8	2.4	58.8	10.6	1.9	2.1	66.8	9.5	1.5	1.5
(100)	S.D.:	26.1	7.0	1.0	5.2	32.0	6.1	1.0	2.0	21.4	1.7	0.6	1.7
	N:		47				39				4		
7	MEAN:	23.8	29.8	2.1	4.5	41.1	22.4	2.0	3.5	52.7	24.3	2.7	1.7
(150)	S.D.:	30.5	16.2	1.2	6.9	36.4	13.4	1.4	5.6	46.1	23.1	2.1	2.1
	N:		47				39				3		
12	MEAN:	68.0	16.6	2.1	1.7	90.3	13.3	2.0	2.4	85.0	25.5	3.0	1.0
(170)	S.D.:	[illegible]	14.5	1.2	2.3	54.2	10.6	1.0	3.5	120.2	29.0	2.8	1.4
	N:		47				37				2		
13	MEAN:	[illegible]	16.8	2.4	1.9	87.6	12.4	[illegible]	1.5	59.0	12.5	1.5	0.5
(170)	S.D.:	62.3	11.1	1.4	1.7	64.9	8.2	1.2	1.4	31.1	7.8	0.7	0.7
	N:		47				38				2		
[illegible]	MEAN:	[illegible]	[illegible]	1.9	0.8	59.9	12.0	[illegible]	0.8	27.5	21.5	2.5	4.0
(100)	S.D.:	52.0	11.9	1.6	1.0	36.7	8.2	1.2	1.1	3.5	9.2	0.7	4.2
	N:		46				38				2		
25	MEAN:	10.4	36.8	2.8	11.1	34.1	30.2	3.1	8.9	23.5	23.0	2.0	2.5
(360)	S.D.:	29.1	9.1	1.0	12.6	67.4	9.0	1.2	9.6	33.2	5.9	1.4	3.5
	N:		46				37				2		
[illegible]	MEAN:	31.4	24.8	2.2	3.1	39.0	21.5	2.1	2.8	48.0	17.0	2.0	2.5
(150)	S.D.:	28.0	12.4	1.4	6.2	26.4	11.4	1.6	3.5	7.1	2.8	1.4	3.5
	N:		46				37				2		
22	MEAN:	[illegible]	19.6	2.5	3.5	103.0	17.6	2.3	3.5	115.5	12.0	2.0	1.0
(260)	S.D.:	65.0	12.5	1.4	2.9	84.1	12.6	[illegible]	3.1	135.1	7.1	1.4	1.4
	N:		46				36				2		
[illegible]	MEAN:	[illegible]	[illegible]	2.0	1.2	61.0	11.3	[illegible]	1.0	0.0	43.0	4.0	1.0
(100)	S.D.:	[illegible]	12.6	1.7	1.9	33.0	8.3	1.2	1.3	0.0	0.0	0.0	0.0
	N:		46				[illegible]				1		
[illegible]	MEAN:	79.5	13.7	2.4	2.7	63.9	20.9	3.3	3.2	150.0	4.0	1.0	0.0
(150)	S.D.:	[illegible]	14.5	[illegible]	3.1	61.1	18.3	2.8	2.9	0.0	0.0	0.0	0.0
	N:		47				41				1		
15	MEAN:	75.4	19.3	2.6	2.3	80.7	19.6	2.1	3.2	0.0	0.0	0.0	0.0
(230)	S.D.:	74.4	[illegible]	[illegible]	2.2	78.7	[illegible]	1.6	4.5	0.0	0.0	0.0	0.0
	N:		47				41				0		
[illegible]	MEAN:	49.7	27.7	2.3	4.9	90.0	19.9	[illegible]	2.2	0.0	0.0	0.0	0.0
(260)	S.D.:	[illegible]	[illegible]	1.6	8.1	75.9	[illegible]	1.1	4.5	0.0	0.0	0.0	0.0
	N:		[illegible]				36				0		
[illegible]	MEAN:	[illegible]	40.7	[illegible]	[illegible]	12.3	39.8	[illegible]	[illegible]	0.0	0.0	0.0	0.0
(230)	S.D.:	[illegible]	[illegible]	[illegible]	[illegible]	27.2	[illegible]	[illegible]	[illegible]	0.0	0.0	0.0	0.0
	N:		[illegible]				[illegible]				[illegible]		
[illegible]	MEAN:	[illegible]	[illegible]	[illegible]	[illegible]	43.4	[illegible]	[illegible]	2.3	0.0	0.0	0.0	0.0
(230)	S.D.:	[illegible]	[illegible]	1.3	7.1	52.7	[illegible]	[illegible]	[illegible]	0.0	0.0	0.0	0.0
	N:		47				36				0		
20	MEAN:	6.4	36.7	2.2	6.2	26.9	34.5	2.1	7.0	0.0	0.0	0.0	0.0
(260)	S.D.:	[illegible]	9.0	1.4	5.5	66.2	12.4	1.4	8.5	0.0	0.0	0.0	0.0
	N:		46				34				0		
[illegible]	MEAN:	111.3	23.2	3.4	2.4	131.7	20.0	[illegible]	1.1	0.0	0.0	0.0	0.0
(200)	S.D.:	47.9	[illegible]	[illegible]	4.2	51.6	10.5	[illegible]	1.2	0.0	0.0	0.0	0.0
	N:		45				26				0		
[illegible]	MEAN:	[illegible]	[illegible]	[illegible]	[illegible]	315.3	19.7	2.9	1.3	0.0	0.0	0.0	0.0
(360)	S.D.:	[illegible]	[illegible]	[illegible]	1.5	[illegible]	11.4	1.7	1.5	0.0	0.0	0.0	0.0
	N:		[illegible]				24				[illegible]		
[illegible]	MEAN:	[illegible]	[illegible]	[illegible]	1.4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.0
([illegible])	S.D.:	[illegible]	[illegible]	1.2	1.8	[illegible]	1.7	[illegible]	[illegible]	[illegible]	0.0	0.0	0.0
	N:		[illegible]				23				0		
[illegible]	MEAN:	[illegible]	[illegible]	3.4	1.9	284.5	19.8	[illegible]	1.5	0.0	0.0	0.0	0.0
(360)	S.D.:	[illegible]	[illegible]	[illegible]	1.6	126.7	12.3	[illegible]	1.5	0.0	0.0	0.0	0.0
	N:		[illegible]				[illegible]				[illegible]		

[a] Numbers in parenthesis indicate maximum possible scores for engagements.

Table A-17

ACR MODULE TWO REPETITIONS

MISSION		FIRST SCORE	FIRST SEC.	FIRST RDS.	FIRST MISS	SECOND SCORE	SECOND SEC.	SECOND RDS.	SECOND MISS
1	MEAN:	74.3	6.9	1.4	1.4	76.2	8.4	1.5	1.1
(100)[a]	S.D.:	30.0	6.3	0.9	3.1	33.9	7.2	1.2	2.1
	N:		23				19		
2	MEAN:	69.0	8.7	1.4	1.5	57.9	10.9	2.0	1.7
(100)	S.D.:	27.2	3.9	0.5	1.9	33.3	6.5	1.1	1.6
	N:		23				19		
4	MEAN:	52.2	13.2	1.8	1.1	46.5	15.3	2.4	1.8
(100)	S.D.:	32.5	8.7	1.0	1.6	37.6	11.3	1.5	1.6
	N:		23				19		
6	MEAN:	62.1	12.8	1.6	0.7	50.9	15.7	2.4	0.9
(100)	S.D.:	33.6	13.1	1.6	1.0	35.8	14.6	2.3	1.0
	N:		23				19		
7	MEAN:	35.8	25.6	2.1	3.7	53.4	16.5	1.6	4.1
(150)	S.D.:	33.4	15.9	1.8	7.9	44.0	6.9	0.7	8.1
	N:		23				19		
10	MEAN:	66.0	18.5	3.0	2.8	66.9	13.1	2.1	2.1
(150)	S.D.:	50.4	17.8	2.9	2.6	59.6	10.6	1.8	3.2
	N:		23				15		
11	MEAN:	45.1	20.7	2.1	5.1	65.6	25.8	1.4	0.6
(150)	S.D.:	32.3	12.2	1.4	10.5	40.0	7.3	0.8	1.5
	N:		23				14		
12	MEAN:	90.7	14.7	2.4	2.1	100.9	14.3	2.1	1.4
(170)	S.D.:	56.3	15.0	1.8	2.3	65.6	13.9	1.7	2.1
	N:		23				14		
13	MEAN:	88.3	15.8	2.4	1.7	123.7	14.5	2.5	0.7
(170)	S.D.:	74.1	12.2	1.5	1.7	73.4	15.8	2.5	1.1
	N:		23				13		
14	MEAN:	113.4	22.2	3.2	2.3	152.2	14.4	2.3	0.7
(200)	S.D.:	53.7	11.8	1.4	2.0	34.3	3.1	0.5	1.0
	N:		23				13		
15	MEAN:	74.4	19.5	2.5	3.7	65.1	20.1	2.8	2.8
(230)	S.D.:	74.6	10.4	1.3	5.2	64.6	11.7	1.4	1.9
	N:		23				12		
16	MEAN:	100.6	23..	3.3	2.1	15..8	14.5	2.4	1.5
(200)	S.D.:	58.5	12.1	1.5	3.2	36.3	5.5	0.7	2.3
	N:		23				8		
17	MEAN:	8.9	45.4	3.9	5.8	4..1	31.3	2.9	2.6
(230)	S.D.:	25.9	19.7	2.1	4.8	77.4	17.5	1.7	3.0
	N:		23				8		
18	MEAN:	..9.1	27.8	2.2	4.0	7...	..7.3	2.8	5.4
(...	S.D.:	...	...	...	...	...	...	...	...
	N:		...				...		
20	MEAN:	20.7	34.2	2.6	4.6	67.3	29.4	2.5	7.0
(260)	S.D.:	15.5	12.2	1.3	6.5	115.1	19.9	2.0	12.8
	N:		22				7		
22	MEAN:	115.3	18.3	2.8	3.5	109.6	16.4	2.4	2.2
(260)	S.D.:	111.7	12.9	1.8	3.2	112.1	13.9	1.7	2.0
	N:		22				5		
23	MEAN:	...	..6	2.2	4.7	..8.0	14.7	1.3	0.7
(260)	S.D.:	0..	...	...	6..	...	...	...	...
	N:		22				3		
24	MEAN:	...	...	2.3	1.7	...	...	...	...
(460)	S.D.:	...	...	1.8	1.5	...	...	...	...
	N:		22				1		
25	MEAN:	...	..7	...	...	...	...	...	...
(380)	S.D.:	100.6	...	...	11.0	...	...	...	...
	N:		22				1		
26	MEAN:	...	...	...	...	...	...	...	...
(460)	S.D.:	...	...	...	...	...	...	...	...
	N:		22				1		

[a] Numbers in parenthesis indicate maximum possible scores for engagements.

Table A-18

Correlations Between MK60 Test Scores, Training Trials, and Dry Fire Scores for AOB Students (N=63)

	DRY FIRE SCORES												
	First Round							Second Round					
PRETEST	Time To Acquire	Time To Lay	Lead Error Optimum	Lead Error Standard	Elevation Error	Radial Error Optimum	Radial Error Standard	Time To Adjust	Lead Error Optimum	Lead Error Standard	Elevation Error	Radial Error Optimum	Radial Error Standard
Score	.03	-.26*	-.[illegible]	-.02	.06	-.13	-.05	-.17	.04	.06	.09	-.02	.00
Seconds	-.11	.16	.[illegible]	.14	.03	.03	.07	.07	.00	-.04	-.08	-.03	-.05
Rounds	-.08	.12	.[illegible]	.03	-.05	.11	.06	.07	.00	-.02	-.06	-.03	-.03
Miss Mils	-.10	.08	.[illegible]	.03	-.08	.17	.13	.01	-.04	-.04	-.04	.22*	.21
Hits	-.09	-.07	-.[illegible]	-.20	-.09	-.11	-.17	-.06	-.13	-.09	.28*	.00	.03
POSTTEST													
Score	.13	-.07	-.[illegible]	-.15	-.07	-.11	-.09	-.06	.02	.03	-.15	.04	.05
Seconds	-.15	.07	.[illegible]	.15	.09	.06	.09	.09	.05	.03	-.01	-.01	-.03
Rounds	-.18	.08	.[illegible]	.06	.09	.13	.06	-.01	.07	.07	-.20	-.11	-.11
Miss Mils	-.16	-.14	.[illegible]	.21	.07	.11	.21*	-.17	-.13	-.13	-.06	.08	.08
Hits	.20	-.01	.[illegible]	-.01	.03	.20	.09	-.06	-.03	-.01	.05	.03	.03
TRAINING TRIALS	-.18	-.01	.[illegible]	-.02	-.05	.10	.03	-.21*	-.14	-.12	-.20	-.07	-.05

*p < .05

**p < .01

Table A-19

Mean Questionnaire Responses from
BAT Students

Items	Low Group (N=35)	High Group (N=35)
Section A. Strongly Disagree (1) to Strongly Agree (5).		
1. I liked practicing on the MK60 training device.	4.66	4.77
2. When I was practicing on the MK60 trainer, I could imagine that I was firing an M60A1 tank.	4.17	4.03
3. If I could see the target, I could hit it.	4.09	4.06
4. Most of the practice engagements were too hard.[a]	3.71	3.83
5. I had trouble finding the targets.[a]	2.89	3.09
6. Practice sessions on the MK60 were too long.[a]	4.2	3.83
7. It bothered me that the ammo handle was in the wrong place on the MK60.[a]	3.66	3.43
8. When practicing on the MK60, I often forgot to say "IDENTIFIED" or "ON THE WAY."[a]	3.86	3.57
9. I really learned how to control the reticle.	4.40	4.43
10. I though the problems on the MK60 were challenging.	4.49	4.26
11. The MK60 helped me learn how to lead moving targets.	4.34	4.31
12. I tried to better my score on the MK60 each time I practiced an engagement.	4.74	4.77
13. It was hard for me to imagine that I was really learning tank gunnery.[a]	3.8	3.43
14. I would like to continue practicing on the trainer when I am assigned to a unit.	4.46	4.31
15. I had too much practice on the MK60 trainer.[a]	4.8	4.03
16. I could train on the MK60 without an assistant instructor.	4.14	4.06
17. The amount of training time I received on the MK60 was not enough to learn M60A1 gunnery.	2.63	2.66
18. I would like to have had more practice time on the MK60 trainer.	4.31	4.06
19. The assistant instructor provided useful coaching on the MK60.	4.14	4.57
20. I learned a lot on the new trainer.	4.40	4.54

[a]Scale is reversed; high numbers represent positive attitude.

Table A-19 (Cont'd)

Items	Low Group (N=35)	High Group (N=35)
Section B. Not At All Realistic (1) to Extremely Realistic (5).		
21. Switches and indicator lights.	3.83	3.57
22. Cadillac controls.	4.03	4.29
23. Sight picture before firing.[b]	3.62	3.69
24. Sight picture after firing.[b]	3.38	3.17
25. Sound effects of tank turret.	2.54	2.94
26. Sound effects of firing.[b]	3.29	3.46
27. Sound of fire commands.	4.11	4.14
Section C. Not At All Helpful (1) to Extremely Helpful (5)		
28. Engagement score.	3.89	4.06
29. Engagement time.	4.09	4.29
30. Number of rounds used.	3.94	3.77
31. Miss distance in mils.	4.09	4.06

[b]For low group, N=34.

Table A-20

ANOVA Summary Table For
"Identified" on MK60 Engagements Used
For Pretest, Posttest, and Training
for BAT Students

Source	df	MS	F
Between Subjects			
Group	2	.699	1.384
Subjects/Group	100	.505	
Within Subjects			
Pre-Post	1	22.946	55.653***
Group x Pre-Post	2	.452	1.095
Pre-Post x Subjects/Group	100	.412	
Items	6	.077	1.717
Group x Items	12	.039	.872
Items x Subjects/Group	600	.045	
Pre-Post x Items	6	.100	2.120**
Group x Pre-Post x Items	12	.030	.644
Pre-Post x Items x Subjects/Group	600	.047	

*$p < .10$

**$p < .05$

***$p < .01$

Table A-21

ANOVA Summary Table For
"On The Way" on MK60 Engagements
For Pretests, Posttests, and Training
for BAT Students

Source	df	MS	F
Between Subjects			
Group	2	1.020	4.271**
Subjects/Group	100	.239	
Within Subjects			
Pre-Post	1	9.277	35.558***
Group x Pre-Post	2	.459	1.759
Pre-Post x Subjects/Group	100	.261	
Items	6	.180	3.382***
Group x Items	12	.082	1.543
Items x Subjects/Group	600	.053	
Pre-Post x Items	6	.077	1.391
Group x Pre-Post x Items	12	.040	.734
Pre-Post x Items x Subjects/Group	600	.055	

*$p < .10$

**$p < .05$

***$p < .01$

Table A-22

ANOVA Summary Table For
Score on MK60 Engagements Used
For Pretests, Posttests, and Training
for BAT Students

Source	df	MS	F
Between Subjects			
Group	2	38283.293	7.086***
Subjects/Group	99	5402.573	
Within Subjects			
Pre-Post	1	1266700.800	477.003***
Group x Pre-Post	2	55323.660	20.833***
Pre-Post x Subjects/Group	99	2655.541	
Items	6	902284.740	303.424***
Group x Items	12	6584.059	2.214***
Items x Subjects/Group	594	2973.678	
Pre-Post x Items	6	56039.133	24.849***
Group x Pre-Post x Items	12	6937.141	3.076***
Pre-Post x Items x Subjects/Group	594	2255.221	

*$p < .10$

**$p < .05$

***$p < .01$

Table A-23

ANOVA Summary Table For
Seconds on MK60 Engagements Used
For Pretest, Posttests, and Training
for BAT Students

Source	df	MS	F
Between Subjects			
Group	2	1209.246	2.890*
Subjects/Group	96	418.393	
Within Subjects			
Pre-Post	1	104462.600	428.519***
Group x Pre-Post	2	2358.907	9.677***
Pre-Post x Subjects/Group	96	243.776	
Items	6	2966.539	15.040***
Group x Items	12	231.670	1.175
Items x Subjects/Group	576	197.243	
Pre-Post x Items	6	452.190	2.814***
Group x Pre-Post x Items	12	257.936	1.605*
Pre-Post x Items x Subjects/Group	576	160.706	

*$p < .10$

**$p < .05$

***$p < .01$

Table A-24

ANOVA Summary Table For
Number of Rounds on MK60 Engagements Used
For Pretest, Posttest, and Training
for BAT Students

Source	df	MS	F
Between Subjects			
Group	2	1.637	.406
Subjects/Group	99	4.035	
Within Subjects			
Pre-Post	1	124.041	45.133***
Group x Pre-Post	2	.388	.141
Pre-Post x Subjects/Group	99	2.748	
Items	6	72.604	32.109***
Group x Items	12	3.010	1.331
Items x Subjects/Group	594	2.261	
Pre-Post x Items	6	10.635	5.458***
Group x Pre-Post x Items	12	2.136	1.096
Pre-Post x Items x Subjects/Group	594	1.948	

*$p < .10$

**$p < .05$

***$p < .01$

Table A-25

ANOVA Summary Table For
Miss in Mils on MK60 Engagements Used
For Pretest, Posttest, and Training
for BAT Students

Source	df	MS	F
Between Subjects			
Group	2	39.415	2.390*
Subjects/Group	92	16.489	
Within Subjects			
Pre-Post	1	938.358	73.020***
Group x Pre-Post	2	5.737	.446
Pre-Post x Subjects/Group	92	12.851	
Items	6	108.912	8.478***
Group x Items	12	9.225	.718
Items x Subjects/Group	552	12.846	
Pre-Post x Items	6	66.688	6.419***
Group x Pre-Post x Items	12	17.149	1.651*
Pre-Post x Items x Subjects/Group	552	10.390	

*$p < .10$

**$p < .05$

***$p < .01$

Table A-26

ANOVA Summary Table For
Number of Hits on MK60 Engagements Used
For Pretest, Posttest, and Training
for BAT Students

Source	df	MS	F
Between Subjects			
Group	2	.459	1.485
Subjects/Group	100	.309	
Within Subjects			
Pre-Post	1	27.715	117.655***
Group x Pre-Post	2	.669	2.841*
Pre-Post x Subjects/Group	100	.236	
Items	6	47.981	333.970***
Group x Items	12	.288	2.007**
Items x Subjects/Group	600	.144	
Pre-Post x Items	6	.962	7.352***
Group x Pre-Post x Items	12	.154	1.173
Pre-Post x Items x Subjects/Group	600	.131	

*$p < .10$

**$p < .05$

***$p < .01$

Table A-27

ANCOVA Summary Table For
"Identified" on MK60 Engagements Used
For Pretest, Posttest, and Training,
With Pretest as Covariate,
for BAT Students

Source (Adjusted)	df	MS	F
Between Subjects			
Group	2	.013	.705
Subjects/Group	99	.019	
Within Subjects			
Items	6	.003	.218
Group x Items	12	.012	.950
Items x Subjects/Group	599	.013	

*p < .10

**p < .05

***p < .01

Table A-28

ANCOVA Summary Table For
"On The Way" on MK60 Engagements Used
For Pretest, Posttest, and Training,
With Pretest as Covariate,
for BAT Students

Source (Adjusted)	df	MS	F
Between Subjects			
Group	2	.074	4.651**
Subjects/Group	99	.016	
Within Subjects			
Items	6	.019	1.005
Group x Items	12	.038	1.994**
Items x Subjects/Group	599	.019	

*p < .10

**p < .05

***p < .01

Table A-29

ANCOVA Summary Table For
Score on MK60 Engagements Used
For Pretest, Posttest, and Training,
With Pretest as Covariate,
for BAT Students

Source (Adjusted)	df	MS	F
Between Subjects			
Group	2	96747.617	26.207***
Subjects/Group	98	3691.689	
Within Subjects			
Items	6	251529.520	81.281***
Group x Items	12	11840.387	3.826***
Items x Subjects/Group	593	3094.561	

*p < .10

**p < .05

***p < .01

Table A-29

ANCOVA Summary Table For
Score on MK60 Engagements Used
For Pretest, Posttest, and Training,
With Pretest as Covariate,
for BAT Students

Source (Adjusted)	df	MS	F
Between Subjects			
Group	2	96747.617	26.207***
Subjects/Group	98	3691.689	
Within Subjects			
Items	6	251529.520	81.281***
Group x Items	12	11840.387	3.826***
Items x Subjects/Group	593	3094.561	

*$p < .10$

**$p < .05$

***$p < .01$

Table A-30

ANCOVA Summary Table For
Seconds on MK60 Engagements Used
For Pretest, Posttest, and Training
With Pretest as Covariate,
for BAT Students

Source (Adjusted)	df	MS	F
Between Subjects			
Group	2	3270.131	20.449***
Subjects/Group	95	159.918	
Within Subjects			
Items	6	917.396	8.187***
Group x Items	12	302.910	2.703***
Items x Subjects/Group	575	112.052	

*$p < .10$

**$p < .05$

***$p < .01$

Table A-31

ANCOVA Summary Table For
Number of Rounds on MK60 Engagements Used
For Pretest, Posttest, and Training,
With Pretest as Covariate,
for BAT Students

Source (Adjusted)	df	MS	F
Between Subjects			
Group	2	.940	.444
Subjects/Group	98	2.119	
Within Subjects			
Items	6	21.813	14.137***
Group x Items	12	2.413	1.564*
Items x Subjects/Group	593	1.543	

*$p < .10$

**$p < .05$

***$p < .01$

Table A-32

ANCOVA Summary Table For
Miss in Mils on MK60 Engagements Used
For Pretest, Posttest, and Training,
With Pretest as Covariate,
for BAT Students

Source (Adjusted)	df	MS	F
Between Subjects			
Group	2	15.081	2.885*
Subjects/Group	91	5.228	
Within Subjects			
Items	6	50.873	10.338***
Group x Items	12	8.267	1.680*
Items x Subjects/Group	551	4.921	

*$p < .10$

**$p < .05$

***$p < .01$

Table A-33

ANCOVA Summary Table For
Number of Hits on MK60 Engagements Used
For Pretest, Posttest, and Training,
With Pretest As Covariate,
for BAT Students

Source (Adjusted)	df	MS	F
Between Subjects			
Group	2	.232	2.900*
Subjects/Group	99	.080	
Within Subjects			
Items	6	12.368	273.029***
Group x Items	12	.099	2.175**
Items x Subjects/Group	599	.045	

*$p < .10$

**$p < .05$

***$p < .01$

Table A-34

ANOVA Summary Table For
"Identified" on MK60 Engagements
Used For Pretest and Posttest
For BAT Students

Source	df	MS	F
Between Subjects			
Group	2	3.647	6.414***
Subjects/Group	99	.569	
Within Subjects			
Pre-Post	1	24.974	44.371***
Group x Pre-Post	2	3.449	6.127***
Pre-Post x Subjects/Group	99	.563	
Items	9	.558	9.515***
Group x Items	18	.112	1.907**
Items x Subjects/Group	891	.059	
Pre-Post x Items	9	.047	.836
Group x Pre-Post x Items	18	.091	1.631**
Pre-Post x Items x Subjects/Group	891	.056	

*p < .10

**p < .05

***p < .01

Table A-35

ANOVA Summary Table For
"On the Way" on MK60 Engagements
Used for Pretest and Posttest
For BAT Students

Source	df	MS	F
Between Subjects			
Group	2	1.350	3.699**
Subjects/Group	99	.365	
Within Subjects			
Pre-Post	1	12.785	35.462***
Group x Pre-Post	2	.222	.615
Pre-Post x Subjects/Group	99	.361	
Items	9	1.627	23.511***
Group x Items	18	.037	.530
Items x Subjects/Group	891	.069	
Pre-Post x Items	9	.595	9.060***
Group x Pre-Post x Items	18	.066	1.001
Pre-Post x Items x Subjects/Group	891	.066	

*p < .10

**p < .05

***p < .01

Table A-36

ANOVA Summary Table For
Score on MK60 Engagements
Used For Pretest and Posttest
For BAT Students

Source	df	MS	F
Between Subjects			
Group	2	10196.902	3.666**
Subjects/Group	98	2781.258	
Within Subjects			
Pre-Post	1	32263.760	17.181***
Group x Pre-Post	2	5370.247	2.860*
Pre-Post x Subjects/Group	98	1877.856	
Items	9	113042.660	123.044***
Group x Items	18	1299.837	1.415
Items x Subjects/Group	882	918.715	
Pre-Post x Items	9	8946.853	9.855***
Group x Pre-Post x Items	18	1166.322	1.285
Pre-Post x Items x Subjects/Group	882	907.851	

*$p < .10$

**$p < .05$

***$p < .01$

Table A-37

ANOVA Summary Table For
Seconds on MK60 Engagements
Used For Pretest and Posttest
For BAT Students

Source	df	MS	F
Between Subjects			
Group	2	199.561	3.700**
Subjects/Group	98	53.929	
Within Subjects			
Pre-Post	1	210.544	5.133**
Group x Pre-Post	2	95.190	2.321
Pre-Post x Subjects/Group	98	41.015	
Items	9	2654.355	131.619***
Group x Items	18	26.987	1.338
Items x Subjects/Group	882	20.167	
Pre-Post x Items	9	182.070	9.353***
Group x Pre-Post x Items	18	19.414	.997
Pre-Post x Items x Subjects/Group	882	19.466	

*$p < .10$

**$p < .05$

***$p < .01$

Table A-38

ANOVA Summary Table For
Number of Rounds on MK60 Engagments
Used for Pretest and Posttest
For BAT Students

Source	df	MS	F
Between Subjects			
Group	2	1.567	1.421
Subjects/Group	96	1.103	
Within Subjects			
Pre-Post	1	75.216	69.866***
Group x Pre-Post	2	.849	.789
Pre-Post x Subjects/Group	96	1.077	
Items	9	11.190	20.301***
Group x Items	18	.773	1.402
Items x Subjects/Group	864	.551	
Pre-Post x Items	9	7.357	15.842***
Group x Pre-Post x Items	18	.561	1.207
Pre-Post x Items x Subjects/Group	864	.464	

*$p < .10$

**$p < .05$

***$p < .01$

Table A-39

ANOVA Summary Table For
Number of Hits on MK60 Engagements
Used For Pretest and Posttest
For BAT Students

Source	df	MS	F
Between Subjects			
Group	2	.665	1.950
Subjects/Group	97	.341	
Within Subjects			
Pre-Post	1	.220	.781
Group x Pre-Post	2	.324	1.150
Pre-Post x Subjects/Group	97	.282	
Items	9	20.701	152.832***
Group x Items	18	.150	1.104
Items x Subjects/Group	873	.135	
Pre-Post x Items	9	.808	5.986***
Group x Pre-Post x Items	18	.089	.660
Pre-Post x Items x Subjects/Group	873	.135	

*$p < .10$

**$p < .05$

***$p < .01$

Table A-40

ANCOVA Summary Table For
"Identified" on MK60 Engagements
Used For Pretest and Posttest
For BAT Students

Source (Adjusted)	df	MS	F
Between Subjects			
Group	2	.102	2.150
Subjects/Group	98	.047	
Within Subjects			
Items	9	.193	5.530***
Group x Items	18	.021	.572
Items x Subjects/Group	890	.036	

*p < .10

**p < .05

***p < .01

Table A-41

ANCOVA Summary Table For
"On The Way" on MK60 Engagements
Used For Pretest and Posttest
For BAT Students

Source (Adjusted)	df	MS	F
Between Subjects			
Group	2	.312	5.358***
Subjects/Group	98	.058	
Within Subjects			
Items	9	.332	7.738***
Group x Items	18	.320	.748
Items x Subjects/Group	890	.043	

*p < .10

**p < .05

***p < .01

Table A-42

ANCOVA Summary Table For
Score on MK60 Engagements
Used For Pretest and Posttest
For BAT Students

Source (Adjusted)	df	MS	F
Between Subjects			
Group	2	14135.242	5.999***
Subjects/Group	97	2356.194	
Within Subjects			
Items	9	59699.618	57.820***
Group x Items	18	1994.118	1.931**
Items x Subjects/Group	881	1032.506	

*$p < .10$

**$p < .05$

***$p < .01$

Table A-43

ANCOVA Summary Table For
Seconds on MK60 Engagements
Used For Pretest and Posttest
For BAT Students

Source (Adjusted)	df	MS	F
Between Subjects			
Group	2	264.283	5.976***
Subjects/Group	97	44.221	
Within Subjects			
Items	9	1363.420	66.519***
Group x Items	18	30.007	1.903**
Items x Subjects/Group	881	20.497	

*$p < .10$

**$p < .05$

***$p < .01$

Table A-44

ANCOVA Summary Table For
Number of Rounds on MK60 Engagements
Used For Pretest and Posttest
For BAT Students

Source (Adjusted)	df	MS	F
Between Subjects			
Group	2	1.550	1.857
Subjects/Group	95	.835	
Within Subjects			
Items	9	11.974	21.306***
Group x Items	18	.890	1.585*
Items x Subjects/Group	863	.562	

*p < .10

**p < .05

***p < .01

Table A-45

ANCOVA Summary Table For
Number of Hits on MK60 Engagements
Used For Pretest and Posttest
For BAT Students

Source (Adjusted)	df	MS	F
Between Subjects			
Group	2	.868	3.511**
Subjects/Group	96	.247	
Within Subjects			
Items	9	7.952	62.609***
Group x Items	18	.145	1.140
Items x Subjects/Group	872	.127	

*$p < .10$

**$p < .05$

***$p < .01$

Table A-46

ANOVA Summary Table for
"Identified" on MK60 Engagements Used
For Posttest Only
For BAT Students

Source	df	MS	F
Between Subjects			
Group	2	.073	.712
Subjects/Group	93	.102	
Within Subjects			
Items	6	1.443	21.190***
Group x Items	12	.086	1.269
Items x Subjects/Group	558	.068	

*$p < .10$

**$p < .05$

***$p < .01$

Table A-47

ANOVA Summary Table for
"On the Way" on MK60 Engagements Used
For Posttest Only
For BAT Students

Source	df	MS	F
Between Subjects			
Group	2	.314	2.540*
Subjects/Group	93	.124	
Within Subjects			
Items	6	2.254	26.672***
Group x Items	12	.234	2.769***
Items x Subjects/Group	558	.085	

*$p < .10$

**$p < .05$

***$p < .01$

Table A-48

ANOVA Summary Table for
Score on MK60 Engagements Used
For Posttest Only
For BAT Students

Source	df	MS	F
Between Subjects			
Group	2	9694.912	4.908***
Subjects/Group	92	1975.507	
Within Subjects			
Items	6	36143.480	30.508***
Group x Items	12	634.564	.536
Items x Subjects/Group	552	1184.710	

*$p < .10$

**$p < .05$

***$p < .01$

Table A-49

ANOVA Summary Table for
Seconds on MK60 Engagements Used
For Posttest Only
For BAT Students

Source	df	MS	F
Between Subjects			
Group	2	136.470	5.416***
Subjects/Group	92	25.198	
Within Subjects			
Items	6	942.650	60.461***
Group x Items	12	9.567	.614
Items x Subjects/Group	552	15.591	

*p < .10

**p < .05

***p < .01

Table A-50

ANOVA Summary Table for
Number of Rounds on MK60 Engagements Used
For Posttest Only
For BAT Students

Source	df	MS	F
Between Subjects			
Group	2	.782	1.053
Subjects/Group	90	.742	
Within Subjects			
Items	6	10.023	21.980***
Group x Items	12	.565	1.238
Items x Subjects/Group	540	.456	

*$p < .10$

**$p < .05$

***$p < .01$

Table A-51

ANOVA Summary Table for
Number of Hits on MK60 Engagements Used
For Posttest Only
For BAT Students

Source	df	MS	F
Between Subjects			
Group	2	.549	2.586*
Subjects/Group	92	.212	
Within Subjects			
Items	6	6.736	47.407***
Group x Items	12	.082	.577
Items x Subjects/Group	552	.142	

*$p < .10$

**$p < .05$

***$p < .01$

Table A-52

BAT Field Trial
Unrotated Factor Matrix
For Twenty Detection Test Items[a]

	Factor		
Item	1	2	3
1	.60	.07	.34
2	.13	-.18	.25
3	.80	-.15	-.20
4	.15	.26	-.33
5	.22	.22	.12
6	.40	.07	-.23
7	.28	.47	.33
8	.52	.01	.14
9	.11	-.57	.07
10	.02	.18	.12
11	.36	.12	-.33
12	.41	.11	-.42
13	.17	.10	-.16
14	.58	-.15	-.11
15	.45	.11	.29
16	.90	-.10	.15
18	.09	-.15	.02
19	.09	.12	-.17
20	.15	-.49	-.04
21	.00	-.01	.17

[a]Two of the original 21 items were perfectly correlated. One was removed for this analysis.

Table A-53

BAT Field Trial
Varimax Rotated Factor
Matrix For Tracking Scores By Trial

	Factor		
	1	2	3
Trial 1			
Time	-.17	.78	.20
Error Distance	.28	.06	.78
Total Distance	.02	.22	.67
Trial 2			
Time	.25	.80	.32
Error Distance	.76	.07	.38
Total Distance	.70	.37	.37
Trial 3			
Time	.46	.79	-.05
Error Distance	.87	-.05	.14
Total Distance	.79	.34	-.08
Trial 4			
Time	.26	.86	.09
Error Distance	.87	.06	.18
Total Distance	.77	.33	-.01

Table A-54

Correlations Between MK60 Test Scores, Training Trials, Ability Tests, and Dry Fire Performance for BAT Students[a]

	DRY FIRE SCORES												
	First Round							Second Round					
PRETEST	Time To Acquire	Time To Lay	Lead Error Optimum	Lead Error Standard	Elevation Error	Radial Error Optimum	Radial Error Standard	Time To Adjust	Lead Error Optimum	Lead Error Standard	Elevation Error	Radial Error Optimum	Radial Error Standard
Score	.08	-.05	-.16	-.12	-.11	-.18	-.15	.05	-.11	-.10	.17	-.05	-.04
Seconds	-.07	.01	.13	.08	.09	.14	.11	.00	.02	.02	-.05	-.02	-.03
Rounds	.12	-.05	-.09	-.06	.00	-.07	-.11	-.23*	-.01	-.02	.29**	.01	.00
Miss Mils	-.03	-.01	.12	.10	.00	.16	.14	-.01	.09	.08	-.14	.07	.07
Hits	.06	-.01	-.03	.01	-.05	-.05	.00	.04	.08	.08	-.03	.10	.11
POSTTEST													
Score	-.17	-.03	-.09	-.12	.02	-.08	-.09	.09	-.05	-.03	.08	.08	.08
Seconds	.20*	.04	.12	.16	.00	.11	.11	-.11	.01	.00	-.04	-.10	-.10
Rounds	.06	-.01	-.09	-.01	-.02	-.04	-.04	-.11	-.09	-.11	.06	-.09	-.09
Miss Mils	.17	-.05	.17	.20*	-.01	.17	.15	-.16	.08	.07	-.03	.03	.02
Hits	-.17	-.20*	-.11	-.17	.07	-.10	-.13	-.04	.03	.03	.04	.04	.03
TRAINING TRIALS	-.06	-.05	.14	.11	-.07	.16	.16	.23*	-.03	-.03	-.01	.08	.08
DETECTION	.17	-.17	.36**	.36**	.06	.32**	.30**	-.12	.05	.07	-.20*	.03	.03
TRACKING TIME	-.11	-.05	.11	.08	.00	.14	.12	.07	-.06	-.07	-.02	-.08	-.10
TRACKING ERROR	-.16	.04	.13	.10	.06	.16	.12	-.09	-.01	-.01	.07	.00	.00

*$p < .05$

**$p < .01$

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Appendix B

Volume I

Dry Fire Recording Problems

Bridgette K. O'Brien

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DRY FIRE SCORING

Complete data collection and scoring, while an ideal of any research project, is not always realized. The obstacles inhibiting the AOB and BAT Dry Fire data collection can be divided into two categories: human errors and equipment malfunctions. Examples of the human errors found during the reduction of Dry Fire data include:

1. Gunner did not say "IDENTIFIED."
2. Gunner or tank commander could not identify target.
3. Tank commander prematurely discontinued engagement.
4. Gunner fired at wrong target.
5. Target was not in camera's view when trigger pulled.
6. Gunner did not turn on main gun switch before pulling trigger.

If the gunner did not say "IDENTIFIED" or did not turn on the main gun switch, the response time for an individual could not be measured. Measurement of a subject's ability to lay the main gun on the target was incomplete frequently because the target was outside the camera's field of view when the trigger was pulled. Field of view was approximately 8-10 mils.

Equipment malfunctions accounted for as much as 65% of the lost data (e.g., B first round data. A representation of the types of equipment problems that occurred are listed below.

1. Audio malfunctions, e.g., intercom or CVC helmut failed to work.
2. Dark or hazy screen.
3. Turret would not traverse.
4. Unstable picture.
5. Trigger pull inoperable.

6. Trigger pull indicator failed to recycle to off.

7. Radio contact between control tower and target lost.

The combination of human errors and equipment malfunctions contributed to the percentages of complete audio and video scores described in further detail below.

AOB. Audio and video scores are listed separately in Table 1. The scores are divided further between first and second rounds. All classes had eight first round engagements and four second round engagements per subject. The percentages of complete first round scores range from 54.7% (Class 1) to 98.4% (Class 2). Second round scores range from 75% (Class 3) to 100% (Class 2) completion. Video scores ranged 58.3 - 89.1% and 33.3 - 71.4%, first and second rounds respectively. Table 2 demonstrates the differences between the two main categories and the classes involved in the project. Human errors generally outnumbered equipment malfunctions for the AOB subjects. Class 1, however, had more first round equipment problems than the other classes.

Tables 3 and 4 give an indication of the differences between classes in relation to the number and percentage of scores not collected. Problems with the gunner's and the TC's radio components contributed to a majority of the 26.1 % lost scores (Class 1). Second round scores often were incomplete because tank commanders would discontinue an engagement if they felt the subject could not complete it. For Class 3 data were incomplete most frequently because the target was outside the camera's range when the trigger was pulled.

BAT. Unlike the AOB classes, the BAT companies performed a varying number of engagements. The number of engagements performed by a unit can be found in the parentheses in Table 5. The table also presents the percent of

Table B-1

Complete Audio and Video Scores
AOB

	1st Round			2nd Round		
	High	Low	Control	High	Low	Control
Class 1						
Audio	73.4%	54.7%	57.1%	100%	90.6%	92.8%
Video	89.1%	87.5%	78.6%	65.6%	62.5%	71.4%
Class 2						
Audio	96.9%	89.1%	98.4%	90.6%	100%	78.1%
Video	62.5%	78.1%	73.4%	43.7%	46.9%	43.7%
Class 3						
Audio	100%	93.7%	80.3%	91.7%	91.7%	75%
Video	58.3%	68.7%	60.7%	37.5%	33.3%	53.6%

Table B-2

Human Errors vs. Equipment Malfunctions (%)
AOB

		HIGH		LOW		CONTROL	
		1st Rd.	2nd Rd.	1st Rd.	2nd Rd.	1st Rd.	2nd Rd.
CLASS 1	Human	33.3	100.0	38.9	92.3	55.6	100.0
	Equipment	66.7	0.0	61.1	7.7	44.4	0.0
CLASS 2	Human	100.0	100.0	66.7	100.0	94.4	96.0
	Equipment	0.0	0.0	33.3	0.0	5.6	4.0
CLASS 3	Human	80.0	71.4	60.0	72.0	44.1	65.0
	Equipment	20.0	28.6	40.0	27.8	55.8	35.0

Table B-3

Total Number of Scores Not Collected
AOB

1st Round

	High	Low	Control	Total	Percent
Class 1	24 (128)	36 (128)	36 (112)	96	26.1
Class 2	26 (128)	21 (128)	18 (128)	65	16.9
Class 3	20 (96)	15 (96)	34 (112)	69	22.7
TOTAL:	70	72	88	230	21.8

( ) = Number of audio and video scores possible.

Table B-4

Total Number of Scores Not Collected
AOB

2nd Round

	High	Low	Control	Total	Percent
Class 1	11 (64)	13 (64)	10 (56)	34	18.5
Class 2	21 (64)	17 (64)	25 (64)	63	32.8
Class 3	14 (48)	18 (48)	20 (56)	52	34.2
TOTAL:	46	48	55	149	(28.2%)

Table B-5

Complete Audio and Video Scores
BAT

	1st Round				2nd Round		
	High	Low	Control		High	Low	Control
"A" (6)				(2)			
Audio	83.3%	95.2%	77.1%		75.0%	78.6%	62.5%
Video	77.7%	57.1%	79.2%		41.7%	21.4%	55.5%
"B" (9)				(4)			
Audio	83.3%	83.3%	72.2%		84.4%	90.6%	71.9%
Video	44.4%	61.1%	33.3%		50.0%	62.5%	40.6%
"C" (10)				(5)			
Audio	85.0%	83.7%	80.0%		85.0%	87.5%	82.8%
Video	75.0%	81.2%	81.4%		47.5%	65.0%	68.6%
"D" (10)				(5)			
Audio	91.1%	91.1%	93.3%		84.4%	82.2%	86.7%
Video	42.2%	38.9%	47.8%		28.9%	22.2%	28.9%

complete engagements for each company. Complete first round audio and video scores range from 77.1% ("B") to 95.2% ("A"), and 38.9% ("D") to 84.4% ("C"), respectively.

In the BAT sample, human errors outweighed equipment malfunctions in three of the four companies. As Table 6 shows, D was the company plagued by equipment difficulties. Most of the equipment problems were not obvious until the tapes were reviewed. Thirty-three percent of the subjects from D did not have any video scores recorded because the picture was unstable. The instability, as explained by personnel at the U.S.A. Armor and Engineer Board, was probably caused by variation in the electrical current of the generator. Other problems included a malfunctioning trigger pull, dark screens, incomplete engagements and unidentifiable targets.

Tables 7 and 8 combine the number of incomplete audio and video scores to give the total number of scores each company lost. The total number of lost scores is also tabulated for the individual group, i.e., High, Low and Control. The percentages of incomplete scores ranged from 18.9% to 36.5%.

Table B-6

Human Errors vs. Equipment Malfunctions (%)
BAT

		HIGH		LOW		CONTROL	
Company		1st Rd.	2nd Rd.	1st Rd.	2nd Rd.	1st Rd.	2nd Rd.
"A"	Human	100.0	90.0	90.0	92.9	66.7	87.5
	Equipment	0.0	10.0	10.0	7.1	33.3	12.5
"B"	Human	71.1	90.5	95.0	93.8	71.2	84.0
	Equipment	28.9	9.5	5.0	6.2	28.8	16.0
"C"	Human	53.1	61.3	64.3	73.7	33.3	76.5
	Equipment	46.8	38.7	35.7	26.3	66.7	23.5
"D"	Human	36.2	55.5	30.2	41.9	35.8	47.2
	Equipment	63.8	44.4	69.8	58.1	64.1	52.8

Table B-7

Total Number of Incomplete Scores
BAT

1st Round

Company	High	Low	Control	Total	Percent
"A"	9 (72)	20 (84)	21 (96)	50	19.8
"B"	52 (144)	40 (144)	66 (144)	158	36.5
"C"	32 (160)	28 (160)	27 (140)	87	18.9
"D"	58 (180)	63 (180)	53 (180)	174	32.2
TOTAL:	151	151	167	469	(27.8)

( ) = Number of audio and video scores possible.

Table B-8

Total Number of Incomplete Scores
BAT

2nd Round

Company	High	Low	Control	Total	Percent
"A"	10 (24)	14 (28)	16 (32)	40	47.6
"B"	21 (64)	16 (64)	25 (64)	62	32.3
"C"	31 (80)	19 (80)	17 (80)	67	29.1
"D"	36 (90)	43 (90)	35 (90)	114	42.2
TOTAL:	98	92	93	283	(36.5)

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Appendix C

Volume I

Instructor Written Comments

From MK60 Evaluation Questionnaire

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BAT instructors who completed the evaluation questionnaire were also invited to make comments to clarify their ratings. The following is a list of those comments by item number. All comments pertain to the MK60.

Item No.	Comment
6.	"Some targets are hard to see."
7.	"Too much color and picture distinction was not very good."
10.	"Computer spring lock."
14.	"O.K. for training purposes."
18.	"Too much time."
Open ended item:	What other information would have been useful to you?
	1. "If there were a sight reticle on the TV set we could give subsequent fire commands."
	2. "Insert a MG engagement."
21.	"Need to be able to stop at a mistake, correct and restart."
22.	"Need to be able to teach more students at once." [This respondent, however, selected the response that training with the MK60 was "somewhat more efficient" compared to training with the M55 Laser.]
23.	"Anytime the student is associated with the true environment of the actual equipment I feel he will do better on the gun range."
25.	"It [the MK60] would increase their ability to identify with fire commands and subsequent fire commands and their reflexes."
28.	Ambiguous comment: "The sound effects would make it better." [Selected response was "somewhat agree" that training with the M55 Laser should be replaced by training on the MK60.]
1.	"Compared to the BOT machine at [the standard training] Holder Complex, this MK60 is great. More realism is shown, such as voice command, round going down range and so forth. The only thing that I feel was not too effective was subsequent fire command, because the TC could not see where the round was landing [with respect to the reticle]. Overall the machine is a good training device for the young soldiers and for NCOs."
2.	"Somehow the heat reticle and combination ballistic reticle should be introduced."
3.	"The MK60 would be great for reinforcement training and the first phase of training for new troops. It would also be good for use on Tables I, II, and III. But I think Table IV should be given on the tank with the .22 and Brewster Device."

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Appendix D

Suggested MK60

Improvements and Modifications

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During construction of lesson plans and the actual implementation of training a number of potential modifications or improvements to the MK60 were discovered. This appendix will highlight some of those suggestions.

1. Add a sight reticle to the instructors TV monitor. The tested version of the MK60 was connected to a video monitor which presented the total scene the gunner was engaging and the hit and miss graphics generated by the MK60 computer. It did not present the gunner's reticle nor isolate the portion of the scene that was in the field of view of the gunner's eyepiece. Addition of the sight reticle to the video monitor display would have several advantages. First, a monitor reticle would allow the students to watch as the instructor demonstrated proper lead strategies and tracking techniques. Second, the monitor reticle would provide to the instructor information about the lead strategies and tracking techniques used by the student gunners. The instructor could tell whether the student was smoothly tracking the targets rather than ambushing the target, i.e., aiming at a point and firing when the target reached that point. Corrective feedback could be given. Third, with a monitor reticle graduated in mils as in the M32 periscope reticle, and in lieu of any of the other modifications discussed below, the instructor could issue subsequent fire commands for fire adjustment practice. Attempts to use subsequent fire commands in BAT training module 1 failed because of the inability of the instructors to estimate the lay of the gunner in relation to the target.

2. Provide additional target videodiscs. Melching, Campbell and Hoffman (1982) initially specified 118 engagements for practice on ten M60A1 training objectives. The number was subsequently reduced to 85 engagements based on descriptions of film material readily available. The twenty training engagements provided by Perceptronics simply did not allow the type of

practice expected. For example, lead strategy is one of the more difficult gunnery skills. To simplify learning leads for moving targets, the Armor School has developed "standard leads" which should be very close to correct for targets moving approximately ten miles per hour. Initial practice should reinforce the use of those leads by providing targets which would be hit only if the standard leads were applied. Of the twenty engagements used for training, six were flank moving targets. Of those six, experience on the MK60 revealed that only one could be hit with the standard lead. For the remaining targets standard leads were too great. This resulted in frustrated students and instructors until instructors realized the problem and quit trying to teach students the standard leads. The COAX and stationary target lessons had to be deleted. Additional training engagements are needed to reduce these training deficits.

3. Add secondary sight reticles. Use of the secondary sight reticles in the M60A1 tank require the gunner first to select the reticle or proportion of the reticle appropriate for the ammunition being fired, and second to select the aiming point on the reticle which is appropriate for the range of of target. Neither of these steps is required when using the primary sight reticle simulated in the MK60. Practice of these two steps cannot be accomplished without adding a method for changing sight reticles.

4. Improve resolution and color stability of gunner's sight picture. The gunner's sight picture is presented by a video screen inside the MK60. The view of the gunner is analogous to looking at a television from about six inches from the screen. The resulting loss of resolution acts to obscure targets that would be detectable if the scene were viewed from an MK60 tank sight. For moving targets, detection is facilitated by the move-

ment of the target. The resolution is more problematic for stationary targets because they become indistinguishable from similar sized vegetation, even if a contrasting colored background makes the vegetation and target stand out. In addition, the color presentation of the MK60 devices seemed to shift and fade with the use of the devices. There was no way for the user to adjust the color to improve the gunner's sight picture.

5. Improve stability of the video picture. For several of the training and testing engagements, the picture would suddenly shift in the gunner's sight and the video monitor. These shifts required abnormal tracking manipulation to engage the targets.

6. Add a method for the instruction to create known first round systematic errors. Perceptronics provided a floppy disc to create system errors requiring students to apply the Burst on Target method of target adjustment. The use of a floppy disc to create systematic errors has a number of drawbacks. First, the instructors do not know what the error is for each engagement. Perceptronics provided cards with the programmed errors indicated. However, the information on those cards did not match the characteristics of rounds actually fired on the MK60. Furthermore, even if the information was correct, such cards tend to get lost. Second, with the floppy disc the error is the same every time an engagement is practiced. Students can soon learn to anticipate the error of any given engagement. Third, practice on engagements with systematic errors cannot be mixed with practice or engagements without these errors because of the delay created by changing the floppy disc and reprogramming the MK60 computer. Thus, students always know whether or not to expect a system error.

7. Add interactive voice synthesizer and computer routine for providing subsequent fire commands. With the current configuration of the MK60, subsequent fire command training proved to be impractical. Furthermore, for multiple target engagements, the command to shift targets had to be assumed or be provided by the instructor. Subsequent fire command training could be accomplished by an instructor if a graduated sight reticle was presented on the video monitor. However, an instructor would be required for each MK60 used for training. A computer routine with a voice synthesizer to sense rounds and issue subsequent fire commands would allow fire adjustment and multiple target practice without an instructor continuously monitoring the students' practice.

8. Add a method for stopping engagements and repeating engagements. During the initial stages of institutional training, M60A1 gunner students were observed making frequent procedural errors. A method for stopping engagements while practicing on the MK60 would provide the instructor with an opportunity to give feedback to students. The engagement could then be repeated.

9. Add a capability to adjust round limits per engagement. The tested version of the MK60 was programmed to allow user selection of a round limit for a set of practice engagements. In the MK60 training modules, that round limit was always set large enough to allow students to attempt every engagement. If a student did run out, the reload button needed to be pressed which recycled the practice set back to the beginning exercise. As a result, students learned to fire rapidly but did not try to conserve rounds. The ability to adjust round limits per engagement would emphasize the need to conserve ammunition and at the same time allow the student to continue through the practice set. Clearly, the current design of the MK60 round selection

more closely simulates the actual M60A1 tank. However, for training purposes, the potential negative reinforcer of running out of rounds and not being able to achieve hits on each engagement would more effectively reduce any tendency toward rapid but imprecise tracking. In addition, the scoring algorithm used by the MK60 could be adjusted to be more sensitive to the number of rounds used. Students did attend to the feedback and tried to improve their scores during training.